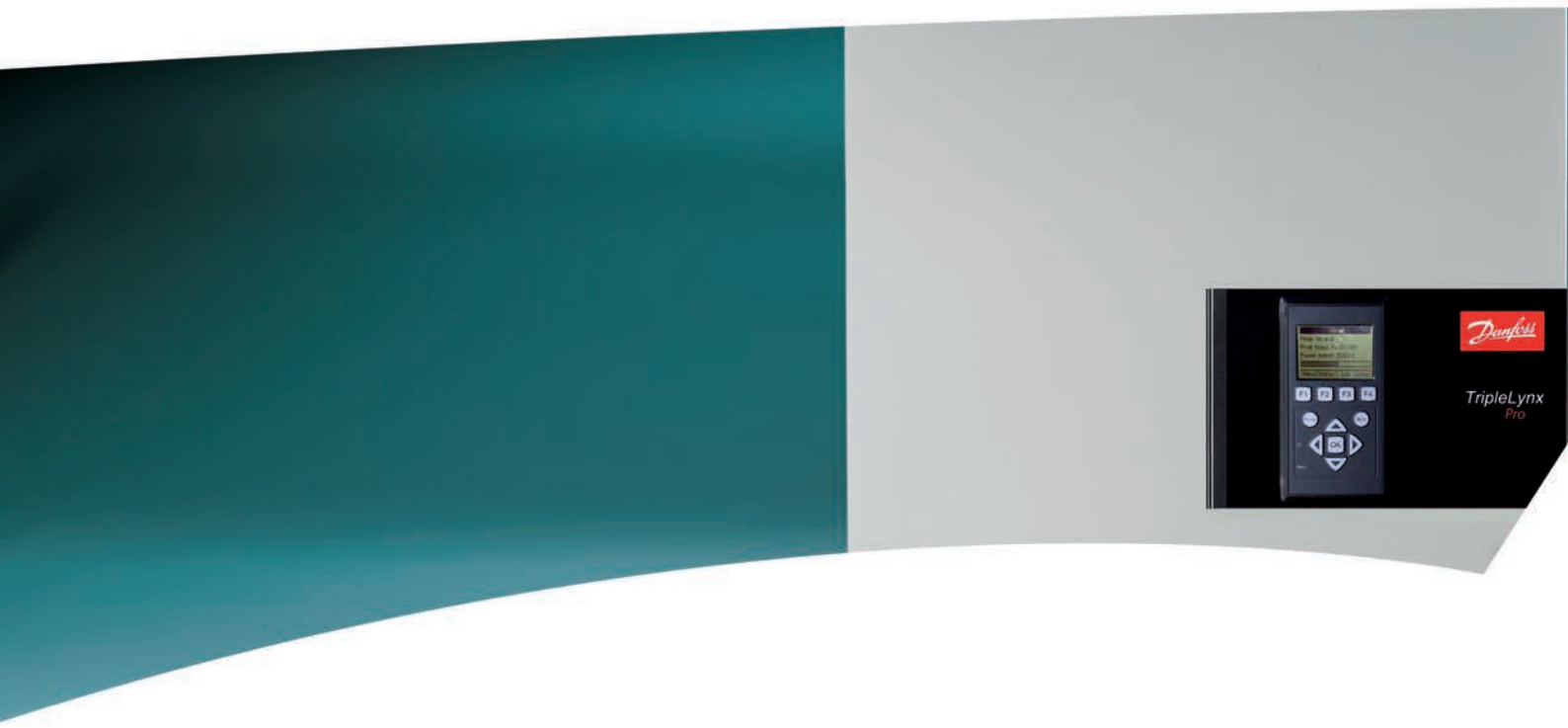
MAKING MODERN LIVING POSSIBLE




# TLX
# Reference Manual

Three-phase – 6k, 8k, 10k, 12.5k and 15k

SOLAR INVERTERS

# Safety and Conformity

## Safety

All persons installing and servicing inverters must be:

- Trained and experienced in general safety rules for work on electrical equipment
- Familiar with local requirements, rules and regulations for the installation

## Safety Message Types

**⚠WARNING**

Safety information important for human safety. Warnings are used for indicating potentially hazardous situations that can cause serious injury or death.

**⚠CAUTION**

Cautions with symbol are used for indicating potentially hazardous situations that can cause minor or moderate injuries.

**CAUTION**

Cautions without symbol are used for indicating situations that may result in equipment or property damage.

**NOTE**

Note is used for indicating highlighted information that should be regarded with attention.

## General Safety

**NOTE**

Before installation
Check for damage to inverter and packaging. If in doubt, contact the supplier before installing the inverter.

**CAUTION**

Installation
For optimum safety, follow the steps described in this manual. Keep in mind that the inverter has two voltage carrying sides; the PV input and the AC grid.

**⚠WARNING**

Disconnecting the inverter
Before starting work on the inverter, switch off AC grid at the mains switch and PV using the PV load switch. Ensure that the device cannot be unintentionally reconnected. Use a voltage tester to ensure that the unit is disconnected and voltage free. The inverter can still be charged with very high voltage at hazardous levels even when it is disconnected from grid/mains and solar modules. Wait at least 30 min. following disconnection from grid and PV panels before proceeding.

**⚠CAUTION**

Maintenance and modification
Only authorised personnel are allowed to repair or modify the inverter. To ensure personal safety, only original spare parts available from the supplier should be used. If non-original spare parts are used, the compliance with CE guidelines in respect of electrical safety, EMC and machine safety is not guaranteed.
The temperature of the cooling racks and components inside the inverter may exceed 70ºC. Observe the danger of burn injury.

**⚠CAUTION**

Functional safety parameters
Never change the parameters of the inverter without authorisation from the local energy supply company and instructions from Danfoss.
Unauthorised changes of functional safety parameters may cause injury or accidents to people or inverter.
Additionally, it will lead to the cancellation of all inverter operating approval certificates and Danfoss warranties. Danfoss cannot be held responsible for such injuries or accidents.

## Hazards of PV Systems

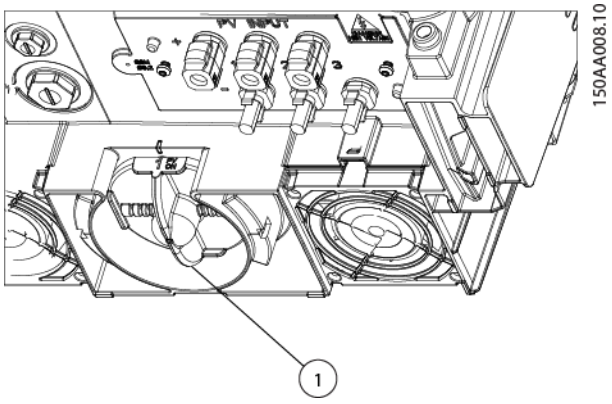
DC voltages up to 1000 V are present in a PV system even when the AC grid is disconnected. Faults or inappropriate use may lead to electric arcing.

**⚠WARNING**

**Do not work on the inverter while disconnecting DC and AC.**

The short-circuit current of the photovoltaic panels is only slightly higher than the maximum operating current and depends on the level of solar irradiation.

## PV Load Switch




The PV load switch (1) enables safe disconnection of DC current.

## Conformity

Go to the download area at www.danfoss.com/solar, Approvals and Certifications, for information.

| | |
|---|---|
| CE | CE marking - This certifies the conformity of the equipment with the regulations which apply in accordance with the directives 2004/108/EC and 2006/95/EC. |

**Table 1.1**

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# 1 Introduction



## 1.1 Introduction

This manual describes planning, installation and basic operation of the TLX Series solar inverters.

**Illustration 1.1 Solar Inverter**

### Chapter Overview

| Chapter | Content |
|---|---|
| 2, 9, 11 | Functions and specifications of the inverter |
| 3, 4, 11 | Pre-installation and planning considerations |
| 5, 6 | Installation of inverters and peripheral units |
| 7 | Local setup and monitoring of the inverter<br>Refer to this chapter for information on obtaining access |
| 8 | Remote setup and monitoring, via web interface access |
| 9 | Ancillary service features, for grid support |
| 10 | Maintenance |
| 12 | Troubleshooting and events |

**Table 1.1 Chapter Overview**

Functional safety and grid management parameters are password protected.

## 1.2 List of Symbols

| Symbol | Explanatory note |
|---|---|
| *Italics* | 1) Indicates reference to a section of the present manual.<br>2) *Italics* are also used to indicate an operation mode, e.g. operation mode *Connecting*. |
| [ ] used in text | 1) Encloses a path of menu navigation.<br>2) Also used to enclose abbreviations such as [kW]. |
| [Plant] | Menu item accessible at plant level. |
| [Group] | Menu item accessible at group level or above. |
| [Inverter] | Menu item accessible at inverter level or above. |
| → | Indicates a step within menu navigation. |
| ✍ | Note, useful information. |
| ! | Caution, important safety information. |
| # ... # | Name of plant, group or inverter in sms or e-mail message, eg. #plant name#. |
| **Site Map** | |
| **Symbol** | **Explanatory note** |
| ↳ | Indicates a submenu. |
| [x] | Defines current security level, where x is between 0-3. |

**Table 1.2 Symbols**

## 1.3 List of Abbreviations

| Abbreviation | Description |
|---|---|
| cat5e | Category 5 twisted pair cable (enhanced) |
| DHCP | Dynamic Host Configuration Protocol |
| DNO | Distribution Network Operator |
| DSL | Digital Subscriber Line |
| EMC (Directive) | Electromagnetic Compatibility Directive |
| ESD | Electrostatic Discharge |
| FRT | Fault ride through |
| GSM | Global System for Mobile communications |
| IEC | International Electrotechnical Commission |
| LED | Light-emitting diode |
| LVD (Directive) | Low Voltage Directive |
| MPP | Maximum power point |
| MPPT | Maximum power point tracking |

1

| Abbreviation | Description |
|---|---|
| P | P is the symbol for active power and is measured in Watts (W) |
| PCB | Printed Circuit Board |
| PCC | Point of common coupling<br>The point on the public electricity network to which other customers are, or could be, connected. |
| PE | Protective Earth |
| PELV | Protected extra-low voltage |
| PLA | Power Level Adjustment |
| $P_{NOM}$ | Power, Nominal conditions |
| POC | Point of connection<br>The point at which the PV system is connected to the public electricity grid. |
| $P_{STC}$ | Power, Standard Test Conditions |
| PV | Photovoltaic, photovoltaic cells |
| RCMU | Residual Current Monitoring Unit |
| $R_{ISO}$ | Insulation Resistance |
| ROCOF | Rate Of Change Of Frequency |
| RTC | Real Time Clock |
| Q | Q is the symbol for reactive power and is measured in reactive volt-amperes (VAr) |
| S | S is the symbol for apparent power and is measured in volt-amperes (VA) |
| STC | Standard test conditions |
| SW | Software |
| THD | Total Harmonic Distortion |
| TN-S | Terre Neutral - Separate. AC Network |
| TN-C | Terre Neutral - Combined. AC Network |
| TN-C-S | Terre Neutral - Combined - Separate. AC Network |
| TT | Terre Terre. AC Network |

**Table 1.3 Abbreviations**

## 1.4 Software Version

Always read the newest version of this manual. This manual is applicable for inverter software 2.0 and onwards. To see the software version, go to

- via the display, [Status → Inverter → Serial no. and SW ver. → Inverter]
- via the web interface, [Inverter level: Status → Inverter → Serial no. and SW ver. → Inverter]

## 1.5 Related Literature

- *TLX Series Installation Manual*
- *TLX Series User Manual*
- *TLX Series Web Server User Manual*
- *Weblogger Manual*
- *CLX Series Quick Guides and User Manuals*
- *GSM Manual*

For more information go to the download area at www.danfoss.com/solar, or contact the supplier of the solar inverter.

# 2 Description of the Inverter



## 2.1 Variants

The TLX Series inverter range comprises the variants:
TLX
TLX+
TLX Pro
TLX Pro+

| | TLX | TLX+ | TLX Pro | TLX Pro+ |
|---|---|---|---|---|
| **Common features** | | | | |
| Power | 6 kVA - 15 kVA | | | |
| Enclosure | IP54 | | | |
| PV connectors | MC4 connectors | | | |
| User interface | Display | | | |
| | Service web interface | | Web interface | |
| Languages | DK, GB, DE, FR, ES, ITA, CZ, NL, GR | | | |

**Table 2.1 Common Features**

2

| | TLX | TLX+ | TLX Pro | TLX Pro+ |
|---|---|---|---|---|
| **Monitoring (Internet)** | | | | |
| FTP (portal) | Optional (retrofit):<br>GSM module[1]<br>(user defined, incl. CLX portal) | | Optional (retrofit):<br>GSM module[5]<br>✓[4] | |
| | Via accessories (only CLX portal):<br>CLX Home[2]<br>CLX Home GM[2]<br>CLX StandardGM[3]<br>Weblogger[5]<br>CLX Standard[3] | | | |
| Email | Weblogger<br>CLX portal<br>(only with a box or GSM module[1]) | | Optional (retrofit):<br>GSM module[5]<br>✓[4] | |
| SMS | Optional (retrofit):<br>GSM module[1] | | | |
| Relay (alarm or self-consumption) | - | | ✓[4] | |
| SolarApp | Via accessories:<br>CLX Home[2]<br>CLX Standard[3]<br>CLX Home GM[2]<br>CLX Standard GM[3] | | ✓[4]<br>Via accessories:<br>CLX Home[2]<br>CLX Standard[3] | |

**Table 2.2 Monitoring (Internet)**

*1) 1 GSM module per inverter.*

*2) RS-485, max. 3 inverters per network.*

*3) RS-485, max. 20 inverters per network.*

*4) Ethernet, max. 100 inverters per network.*

*5) Max. 50 inverters per network.*

| | TLX | TLX+ | TLX Pro | TLX Pro+ |
|---|---|---|---|---|
| **Monitoring (local)** | | | | |
| User Interface | Display for simple configuration and monitoring | | | |
| | - | | Built-in web interface for advanced configuration and monitoring (via Ethernet) | |

**Table 2.3 Monitoring (Local)**

| | TLX | TLX+ | TLX Pro | TLX Pro+ |
|---|---|---|---|---|
| **Danfoss[5] Grid management** | | | | |
| Remotely controlled active power /PLA | CLX Home GM[2]<br>CLX Standard GM[3] | | CLX GM[4]<br>CLX Home GM[2]<br>CLX Standard GM[3] | |
| Remotely controlled reactive power | - | CLX Home GM[2]<br>CLX Standard GM[3] | CLX GM[4]<br>CLX Home GM[2]<br>CLX Standard GM[3] | |
| Dynamic reactive power (PF(P) | - | ✓ | - | ✓ |
| Dynamic reactive power Q(U) | - | | | ✓ |
| Constant reactive power PF and Q | - | CLX Home GM[2]<br>CLX Standard GM[3] | - | ✓[4] |
| Fixed active power (P) limit | ✓ | | | |
| Fixed apparent power (S) limit | ✓ | | | |
| Closed loop reactive power control | - | ✓[6] | - | ✓[6] |
| Open loop reactive power control | - | CLX Home[2]<br>CLX Standard GM[3] | - | ✓[4] |

**Table 2.4 Grid Management**

*1) Max. 50 inverters per network.*

*2) Max. 3 inverters per network.*

*3) Max. 20 inverters per network.*

*4) Ethernet, max. 100 inverters per network.*

*5) Or by other third-party products, via RS-485.*

*6) By third-party product.*

| | TLX | TLX+ | TLX Pro | TLX Pro+ |
|---|---|---|---|---|
| **Commissioning** | | | | |
| Setup wizard | ✓[4] (display) | | ✓[4] (display and web interface) | |
| Replication of settings (network of inverters) | - | - | ✓[4] | |
| PV sweep | Service web interface | | Web interface | |

**Table 2.5 Commissioning**

*4) Ethernet, max. 100 inverters.*

2

### Product Label

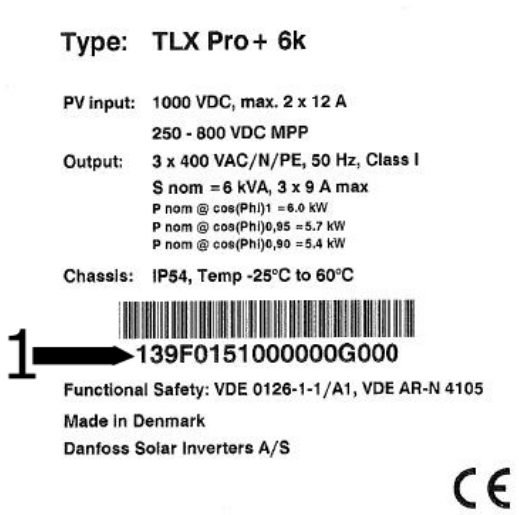
Type: TLX Pro+ 6k
PV input: 1000 VDC, max. 2 x 12 A
250 - 800 VDC MPP
Output: 3 x 400 VAC/N/PE, 50 Hz, Class I
S nom =6 kVA, 3 x 9 A max
P nom @ cos(Phi)1 =6.0 kW
P nom @ cos(Phi)0,95 =5.7 kW
P nom @ cos(Phi)0,90 =5.4 kW
Chassis: IP54, Temp -25°C to 60°C
1
139F0151000000G000
Functional Safety: VDE 0126-1-1/A1, VDE AR-N 4105
Made in Denmark
Danfoss Solar Inverters A/S
CE

Illustration 2.1 Product Label

The product label on the side of the inverter shows:

- Inverter type
- Important specifications
- Serial number, see (1), for identification by Danfoss

## 2.2 Mechanical Overview of inverter

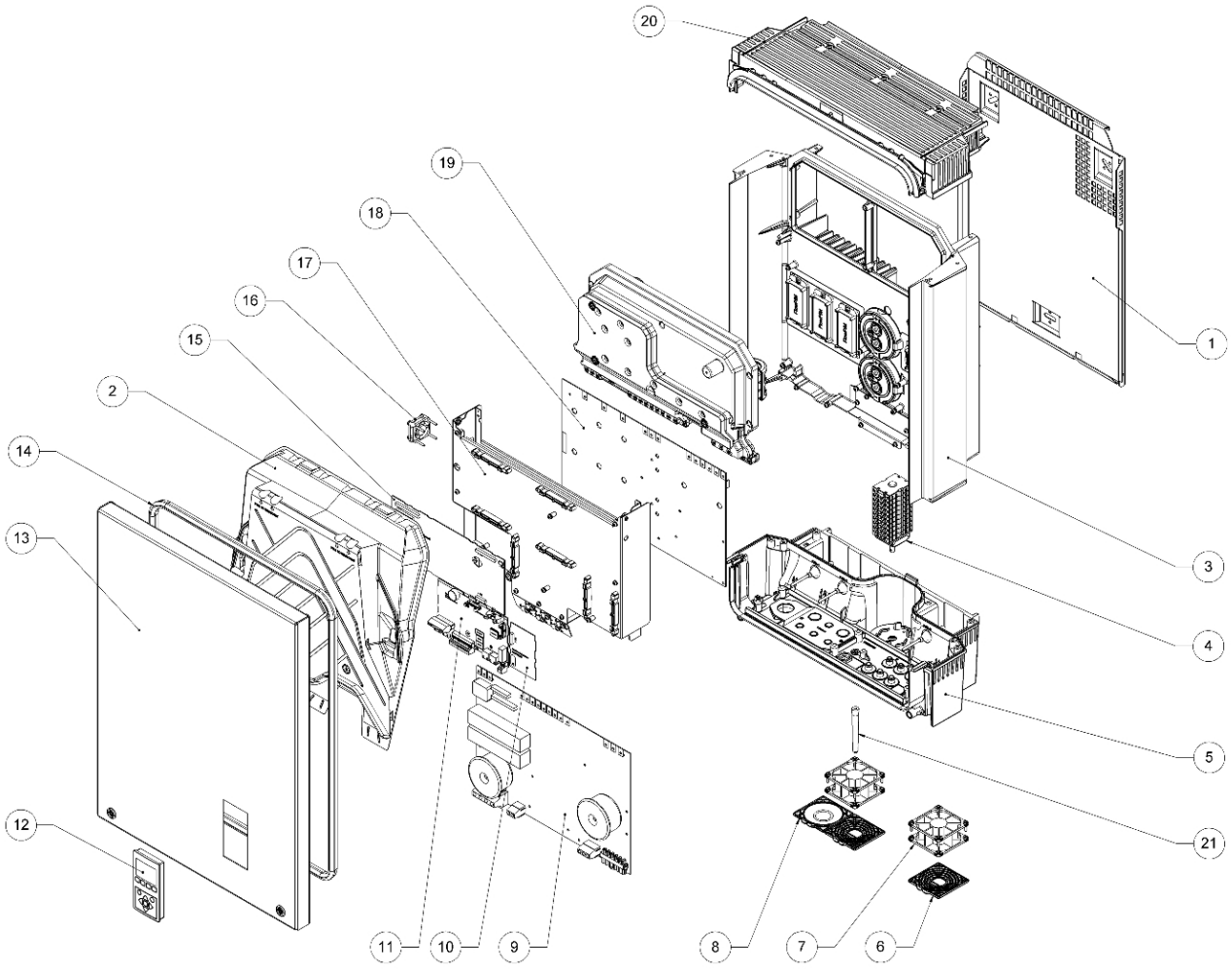


**Illustration 2.2 Mechanical Overview of the Inverter**

| Item # | Part Name | | Item # | Part Name |
|---|---|---|---|---|
| 1 | Wall Plate | | 12 | Display |
| 2 | Condensing Cover | | 13 | Front cover |
| 3 | Heatsink | | 14 | Front cover gasket |
| 4 | PV load switch | | 15 | Control board |
| 5 | Base plate | | 16 | Internal fan |
| 6 | Fan grill | | 17 | Mounting plate for PCB |
| 7 | External fan | | 18 | Power board |
| 8 | Fan hole cover | | 19 | Coil box |
| 9 | Aux. board | | 20 | Top plate |
| 10 | GSM modem (optional) | | 21 | GSM antenna (optional) |
| 11 | Communication board | | | |

**Table 2.6 Legend to *Illustration 2.2*, Inverter Components**

2

## 2.3 Description of the Inverter

### 2.3.1 Functional Overview

The TLX Series comprises transformerless, three-phase inverters with a high performance 3-level inverter bridge. For maximum flexibility the inverter has 2 or 3 separate inputs and equivalent number of MPP trackers. The inverter has an integrated residual current monitoring unit, insulation test functionality and an integrated PV load switch. To support reliable power generation during grid faults, the inverter has extended fault ride through capabilities. The inverter supports a wide range of international grid requirements.

The inverter has a wide range of interfaces:

- User interface
  - Display
  - Service web interface (TLX and TLX+)
  - web interface (TLX Pro and TLX Pro+)
- Communication interface:
  - Standard RS-485
  - Optional GSM modem
  - Ethernet (TLX Pro and TLX Pro+)
- Sensor inputs
  - S0 metering input
  - Irradiation sensor input (reference cell)
  - 3 x Temperature inputs (PT1000)
- Alarm outputs
  - 1 x potential free relay

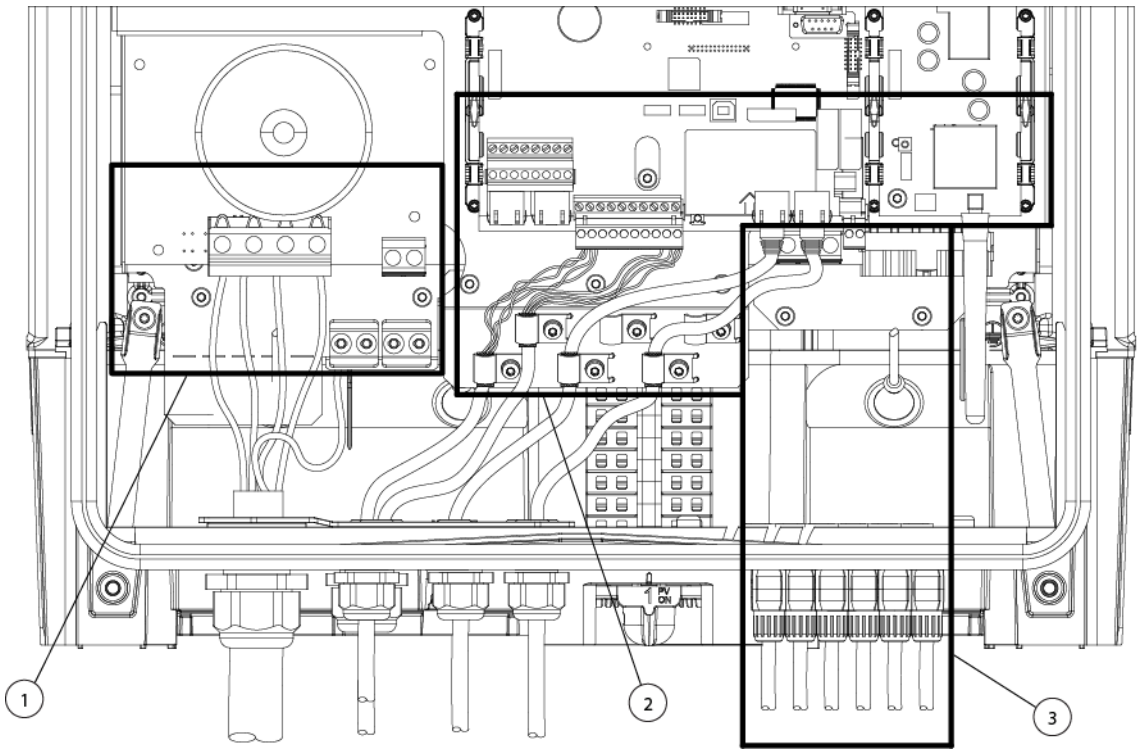


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**Illustration 2.3 Overview of Connection Area**

| | |
|---|---|
| 1 | AC connection area, see *5.5 AC Grid Connection*. |
| 2 | Communication, see *6 Connection of Peripheral Units*. |
| 3 | DC connection area, see *5.7 PV Connection*. |

**Table 2.7 Legend to *Illustration 2.3***

## 2.3.2 Functional Safety

The inverters are designed for international use, with functional safety circuit design meeting a wide range of international requirements (see *2.3.3 International Inverter*).

**Single-fault Immunity**
The functional safety circuit is designed with two independent monitoring units, each having control of a set of grid-separation relays to guarantee single-fault immunity. All functional safety circuits are tested during start-up to ensure safe operation. If a circuit fails more than once out of three times during the self-test, the inverter goes into fail safe mode. If the measured grid voltages, grid frequencies or residual current during normal operation differ too much between the two independent circuits, the inverter ceases to energise the grid and repeats the self-test. The functional safety circuits are always activated and cannot be disabled.

**Grid Surveillance**
The grid is under constant surveillance when the inverter energises the grid. The following parameters are monitored:

- Grid voltage magnitude (instantaneous and 10-minute average)
- Grid voltage frequency
- Three-phase Loss-of-Mains (LoM) detection
- Rate-of-Change-of-Frequency (ROCOF)
- DC content of grid current
- Residual Current Monitoring Unit (RCMU)

The inverter ceases to energise the grid if one of the parameters violates the grid code. The insulation resistance between the PV arrays and earth is also tested during the self-test. The inverter will not energise the grid if the resistance is too low. It will then wait 10 minutes before making a new attempt to energise the grid.

**The inverter has four operation modes**
For information on LEDs, refer to *7.1 Integrated Display Unit*.

**Off grid** (LEDs off)
When no power has been delivered to the AC grid for more than 10 minutes, the inverter disconnects from the grid and shuts down. This is the normal night mode. The user and communication interfaces are still powered for communication purposes.

**Connecting** (Green LED flashing)
The inverter starts up when the PV input voltage reaches 250 V. The inverter performs a series of internal self-tests, including PV auto detection and measurement of the resistance between the PV arrays and earth. Meanwhile, it also monitors the grid parameters. When the grid parameters have been within the specifications for the required amount of time (depends on grid code), the inverter starts to energise the grid.

**On grid** (Green LED on)
The inverter is connected to the grid and energises the grid. The inverter disconnects if: It detects abnormal grid conditions (depending on grid code), if an internal event occurs or if no PV power is available (no power is supplied to the grid for 10 minutes). It then goes into connecting mode or off grid mode.

**Fail Safe** (Red LED flashing)
If the inverter detects an error in its circuits during the self-test (in connecting mode) or during operation, the inverter enters fail safe mode, disconnecting from PV. The inverter will remain in fail safe mode until PV power has been absent for a minimum of 10 minutes, or the inverter has been shut down completely (AC and PV).

Refer to *10.1 Troubleshooting* for further information.

## 2.3.3 International Inverter

The inverter is equipped with a range of grid codes to meet national requirements.
Before connecting an inverter to the grid, obtain approval from the local distribution network operator (DNO).
For initial selection of grid code, refer to *7.4 Start-up and Check of Settings*.

View the current grid code setting

- via the display at [Status → Inverter]
- via the web interface at [Inverter level: Status → Inverter → General].

To change the grid code

- for security level 2, obtain a 24-hour username and password from Service
- log on using the username and password provided (security level 2)
- select grid code

- via the display at [Setup → Setup details]
- via the web interface at [Inverter level: Setup → Setup details]

For further information, see *3.2 Change Procedure*.
For details of individual grid codes, contact Danfoss.
Selection of a grid code activates a series of settings as follows:

**Grid power quality enhancement settings**
For further information, see *9 Ancillary Services*.

**Functional safety settings**

- The cycle RMS values of the grid voltages are compared with two lower and two upper trip settings, e.g. overvoltage (stage 1). If the RMS values violates the trip settings for more than the duration of "clearance time", the inverter ceases to energise the grid.
- Loss of Mains (LoM) is detected by two different algorithms:
  1. Three-phase voltage surveillance (the inverter has individual control of the three-phase currents). The cycle RMS values of the phase-phase grid voltages are compared with a lower trip setting. If the RMS values violate the trip settings for more than the duration of "clearance time", the inverters cease to energise the grid.
  2. Rate of change of frequency (ROCOF). The ROCOF values (positive or negative) are compared to the trip settings and the inverter ceases to energise the grid when the limits are violated.
- Residual current is monitored. The inverter ceases to energise the grid when:
  - the cycle RMS value of the residual current violates the trip settings for more than the duration of "clearance time"
  - a sudden jump in the DC value of the residual current is detected.
- Earth-to-PV isolation resistance is monitored during start-up of the inverter. If the value is too low, the inverter will wait 10 minutes and then make a new attempt to energise the grid. **Note:** The value is offset by 200 kΩ in order to allow for measuring inaccuracy.
- If the inverter ceases to energise the grid due to grid frequency or grid voltage (not three-phase LoM), and if the frequency or voltage is restored within a short time (short-interruption time), the inverter can reconnect when the grid parameters have been within their limits for the specified time (reconnect time). Otherwise, the inverter returns to the normal connection sequence.

See *9 Ancillary Services* for additional non-safety functionalities which are grid code specific.

### 2.3.4 Derating

Derating the output power is a means of protecting the inverter against overload and potential failure.
Furthermore, derating can also be activated to support the grid by reducing or limiting the output power of the inverter. Derating is activated by:

1. PV over-current
2. Internal over-temperature
3. Grid overvoltage
4. Grid overfrequency[1]
5. External command (PLA feature)[1]

*1) See 9 Ancillary Services.*

Derating is accomplished by adjusting the PV voltage and subsequently operating outside the maximum power point of the PV arrays. The inverter continues to reduce the power until the potential overload ceases or the PLA level is reached. The total amount of time the inverter has derated can be seen in the display [Log → Derating], security level 1.
Derating due to PV current or grid power indicates that too much PV power has been installed, whereas derating due to grid current, grid voltage and grid frequency indicate issues with the grid.
See *9 Ancillary Services* for more information.

During temperature derating, the output power may fluctuate by up to 1.5 kW.

**1. PV Over-current**
The inverter will move PV voltage until current reaches 12 A max. If 12 A max. is exceeded, the inverter disconnects from the grid.

**2. Internal Over-temperature**
Derating due to temperature is a sign of excessive ambient temperature, a dirty heatsink, a blocked fan or similar.
Refer to *10.2 Maintenance* for advice.

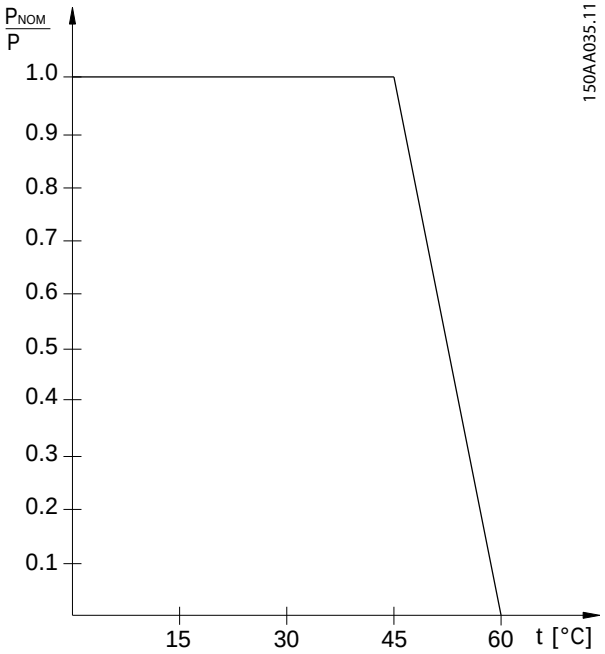


Illustration 2.4 Derating Temperature

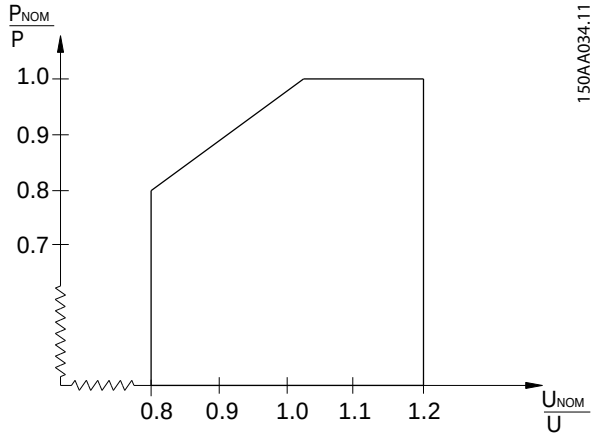


Illustration 2.6 Grid Voltage Lower than $U_{nom}$

### 3. Grid Overvoltage

When the grid voltage exceeds a DNO defined limit *U1* , the inverter derates the output power. If the grid voltage increases and exceeds the defined limit *10 min mean (U2)*, the inverter ceases to energise the grid, in order to maintain power quality and protect other equipment connected to the grid.

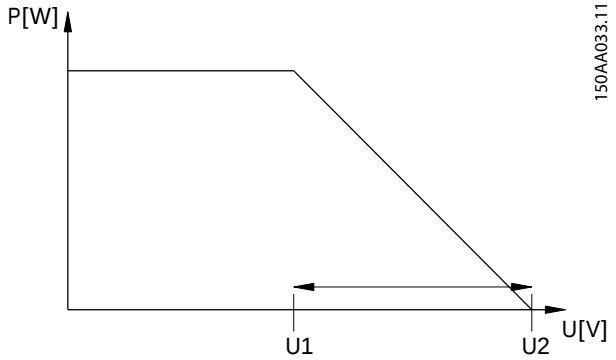


Illustration 2.5 Grid Voltage above Limit Set by DNO

| | |
|---|---|
| U1 | Fixed |
| U2 | Trip Limit |

Table 2.8 Legend to *Illustration 2.5*

At grid voltages lower than the nominal voltage (230 V), the inverter will derate to avoid exceeding the current limit.

2

## 2.3.5 MPPT

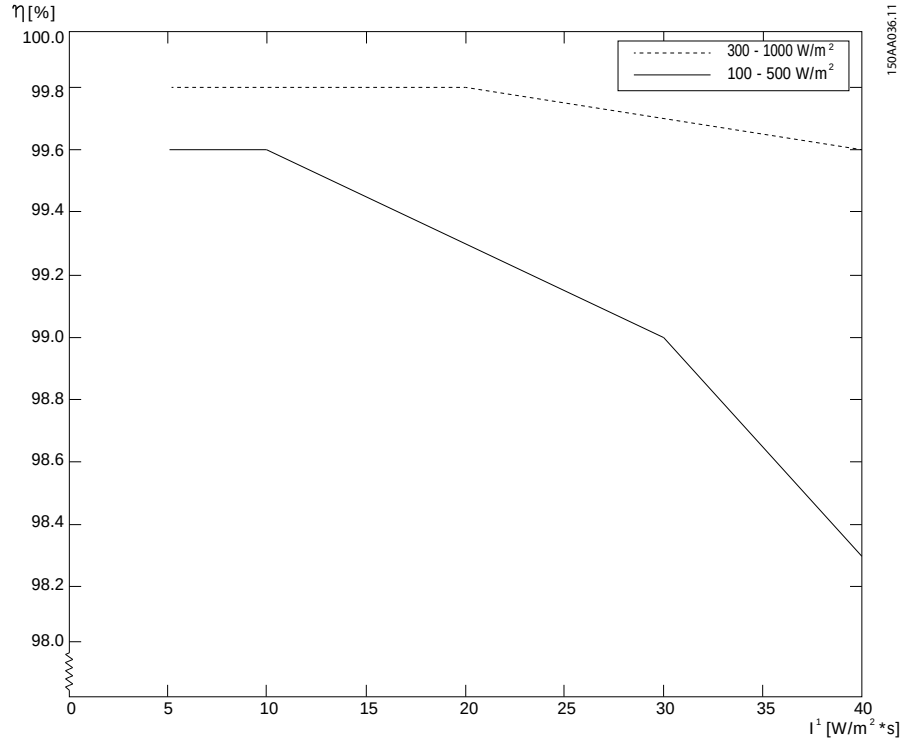


**Illustration 2.7 Measured MPPT Efficiency for Two Different Ramp Profiles.**

A Maximum Power Point Tracker (MPPT) is an algorithm which is constantly trying to maximise the output from the PV array. The MPPT algorithm is based on the Incremental-Conductance algorithm. The algorithm updates the PV voltage fast enough to follow rapid changes in solar irradiance, 30 W/(m$^2$*s).

## 2.3.6 PV Sweep

The characteristic power curve of a PV string is non-linear, and in situations where PV panels are partly shadowed, for example by a tree or a chimney, the curve can have more than one local maximum power point (local MPP). Only one of the points is the true global maximum power point (global MPP). Using PV sweep the inverter locates the global MPP, rather than just the local MPP. The inverter then maintains production at the optimum point, the global MPP.

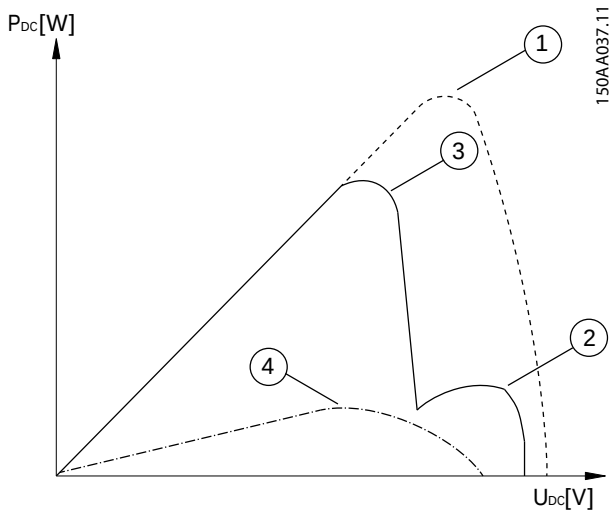


Illustration 2.8 Inverter Output, Power (W) versus Voltage (V)

| | |
|---|---|
| 1 | Fully irradiated solar panels - Global MPP |
| 2 | Partly shaded solar panels - Local MPP |
| 3 | Partly shaded solar panels - Global MPP |
| 4 | Cloudy conditions - Global MPP |

Table 2.9 Legend to *Illustration 2.8*

PV sweep functionality comprises two options for scanning of the entire curve:

- Standard sweep – regular sweep at a pre-programmed interval
- Forced sweep

### Standard sweep

Use standard sweep to optimise yield when there are permanent shadows on the PV panel. The characteristic will then be scanned at the defined interval to ensure production remains at the global MPP.

Procedure:

**Plant level**

In the web interface:

1. Go to [Plant level: Setup → PV Sweep → Sweep type]. Select 'Standard sweep'.
2. Go to [Plant level: Setup → PV Sweep → Sweep interval]. Enter the desired sweep interval in minutes.

**Inverter level**

In the web interface:

1. Go to [Inverter level: Setup → PV Sweep → Sweep type]. Select 'Standard sweep'.
2. Go to [Inverter level: Setup → PV Sweep → Sweep interval]. Enter the desired sweep interval in minutes.

### Forced sweep

Forced sweep operates independently of the standard sweep functionality and is intended for long-term evaluation of the PV panels. The recommended procedure is to perform an initial forced sweep after commissioning and save the results in a log file. Comparison of future sweeps to the initial sweep will indicate the extent of power loss due to degeneration of the solar panels over time. For comparable results, ensure similar conditions (temperature, irradiation, etc.).

Procedure:

**Inverter level only**

- Go to [Inverter level: Setup → PV Sweep]
  - Click on 'Force sweep'.

A forced sweep comprises the following steps:

1. Disconnection of inverter from the grid.
2. Measurement of open-circuit voltage of the PV panels.
3. Reconnection of inverter to the grid.
4. Resumption/completion of PV sweep.
5. Resumption of normal production.

To view the result of the most recent PV sweep performed, go to

- [Inverter level: Inverter → Status → PV sweep]
- [Plant level: Plant → Status → PV sweep]

For further information, see the *TLX Series Web Server Manual*:

- Chapter 4, *PV Sweep*[0] [Plant, Inverter]
- Chapter 6, *PV Sweep*[0] [Plant, Inverter]

## 2.3.7 Efficiency

The conversion efficiency has been measured with a Yokogawa WT 3000 precision power analyser over a period of 250 sec., at 25 °C and 230 V AC grid. The efficiency for each inverter rating are depicted below:

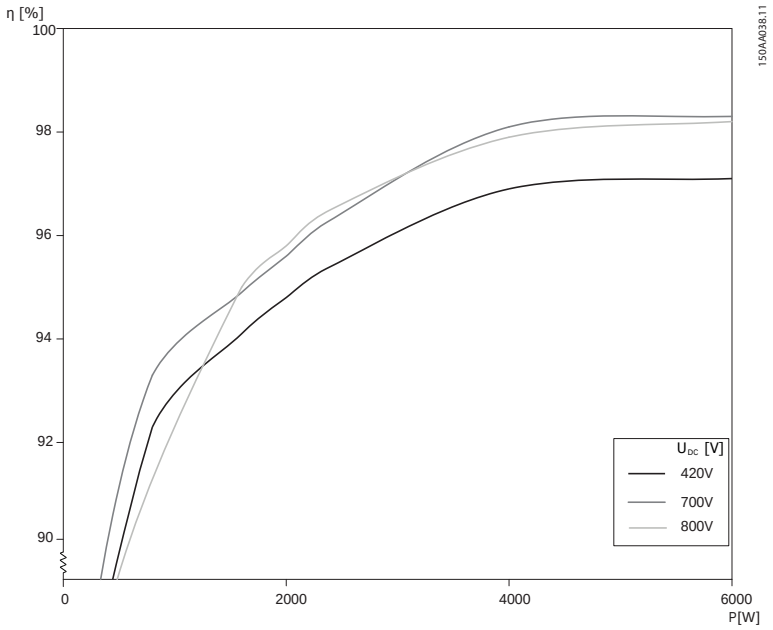


**Illustration 2.9 Efficiency TLX Series 6k: Efficiency [%] versus AC Power [kW]**

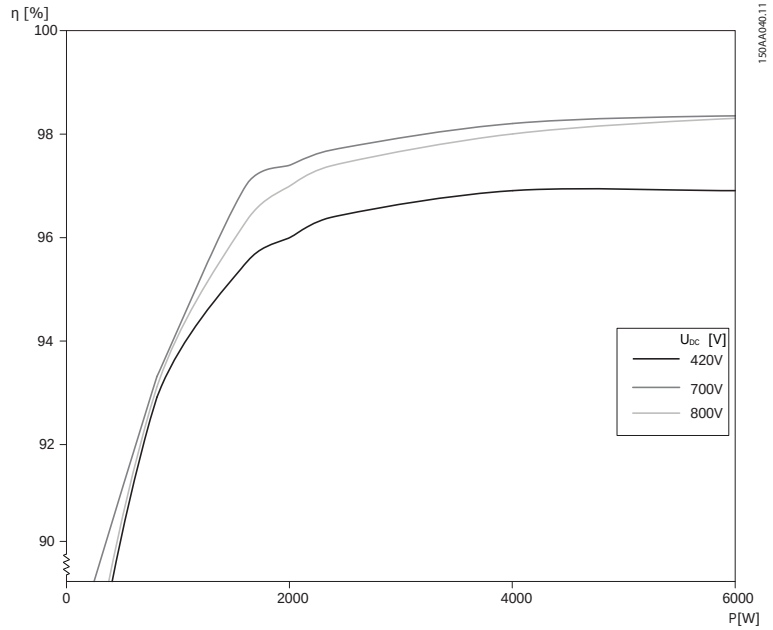


**Illustration 2.10 Efficiency TLX Series 8k: Efficiency [%] versus AC Power [kW]**

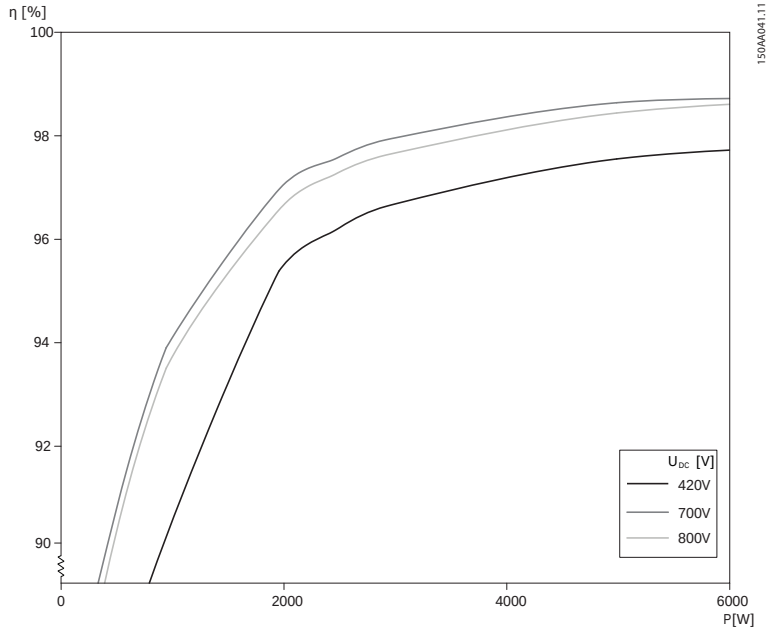


Illustration 2.11 Efficiency TLX Series 10k: Efficiency [%] versus AC Power [kW]

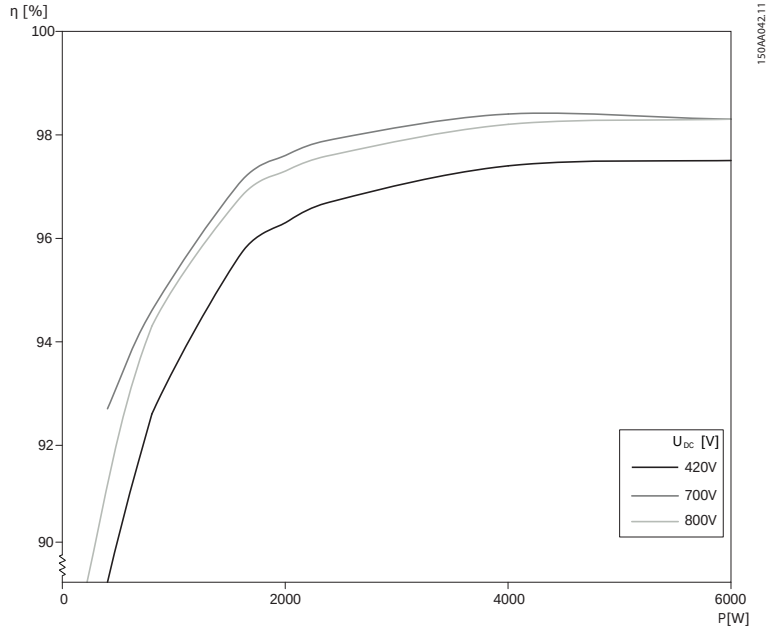


Illustration 2.12 Efficiency TLX Series 12.5k: Efficiency [%] versus AC Power [kW]

2

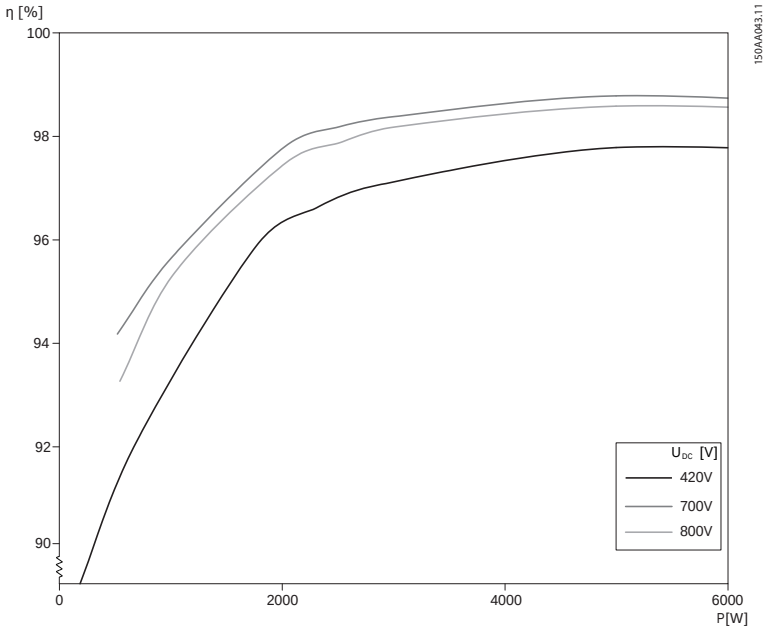


Illustration 2.13 Efficiency TLX Series 15k: Efficiency [%] versus AC Power [kW]

| | TLX Series | | | | | |
|---|---|---|---|---|---|---|
| | 6k | | | 8k | | |
| $P_{NOM}$/P | 420 V | 700 V | 800 V | 420 V | 700 V | 800 V |
| 5% | 88.2% | 89.6% | 87.5% | 88.2% | 90.9% | 88.1% |
| 10% | 91.8% | 92.8% | 91.4% | 92.4% | 92.8% | 92.6% |
| 20% | 93.6% | 94.4% | 94.5% | 95.0% | 96.5% | 95.8% |
| 25% | 94.% | 95.1% | 95.3% | 95.5% | 96.9% | 96.5% |
| 30% | 94.9% | 95.8% | 96.0% | 95.9% | 97.2% | 96.9% |
| 50% | 96.4% | 97.6% | 97.4% | 96.4% | 97.7% | 97.5% |
| 75% | 96.6% | 97.8% | 97.7% | 96.4% | 97.8% | 97.8% |
| 100% | 96.7% | 97.8% | 97.9% | 96.4% | 97.8% | 97.9% |
| EU | **95.7%** | **97.0%** | **96.7%** | **96.1%** | **97.3%** | **97.3%** |

Table 2.10 Efficiencies TLX Series 6k and TLX Series 8k

| | TLX Series | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 10k | | | 12.5k | | | 15k | | |
| $P_{NOM}$/P | 420 V | 700 V | 800 V | 420 V | 700 V | 800 V | 420 V | 700 V | 800 V |
| 5% | 87.3% | 90.4% | 89.1% | 89.5% | 92.2% | 91.1% | 91.1% | 93.4% | 92.5% |
| 10% | 90.6% | 92.9% | 92.5% | 92.1% | 94.1% | 93.8% | 93.1% | 94.9% | 94.6% |
| 20% | 94.4% | 96.0% | 95.6% | 95.2% | 96.6% | 96.3% | 95.7% | 97.0% | 96.7% |
| 25% | 95.2% | 96.6% | 96.3% | 95.8% | 97.1% | 96.8% | 96.2% | 97.4% | 97.1% |
| 30% | 95.7% | 97.0% | 96.7% | 96.2% | 97.4% | 97.1% | 96.5% | 97.6% | 97.4% |
| 50% | 96.6% | 97.7% | 97.5% | 96.9% | 97.9% | 97.7% | 97.0% | 98.0% | 97.8% |
| 75% | 96.9% | 97.8% | 97.8% | 97.0% | 97.8% | 97.8% | 96.9% | 97.8% | 97.7% |
| 100% | 97.1% | 97.9% | 97.9% | 97.0% | 97.8% | 97.9% | 96.9% | 97.7% | 97.9% |
| EU | **95.7%** | **97.0%** | **96.7%** | **96.1%** | **97.3%** | **97.3%** | **96.4%** | **97.4%** | **97.4%** |

Table 2.11 Efficiencies TLX Series 10k, TLX Series 12.5k and TLX Series 15k

### 2.3.8 Internal Overvoltage Protection

**PV Overvoltage Protection**

PV overvoltage protection is a feature that actively protects the inverter and PV modules against overvoltage. The function is independent of grid connection and remains active as long as the inverter is fully functional.
During normal operation the MPP voltage will be in the 250 – 800 V range and the PV overvoltage protection remains inactive. If the inverter is disconnected from grid the PV voltage will be in an open circuit scenario (no MPP tracking). Under these conditions and with high irradiation and low-module temperature, the voltage may rise and exceed 860 V. At this point, overvoltage protection activates.
When the PV overvoltage protection activates, the input voltage is virtually short-circuited (forced to reduce to approximately 5 V), leaving just enough power to supply the internal circuits. The input voltage reduction is performed within 1.5 ms.
When normal grid condition is re-established, the inverter will exit the PV overvoltage protection, returning MPP voltage to a level in the 250-800 V range.

**Intermediate Overvoltage Protection**

During start-up (before the inverter is connected to grid) and while PV is charging the intermediate circuit, the overvoltage protection may be activated to prevent overvoltage in the intermediate circuit.

## 2.4 Autotest Procedure

An automatic test of the inverter can be initialised by activating the inverter autotest procedure:

- Via the display, go to [Setup → Autotest] and press OK.
- Via the web interface, go to [Inverter level: Setup → Setup details → Autotest] and click on [Start → Test].

The inverter autotest manual can be downloaded from www.danfoss.com/solar.

# 3 Change of Functional Safety and Grid Code Settings



## 3.1 Functional Safety Settings

The inverter is designed for international use and it can handle a wide range of requirements related to functional safety and grid behaviour. Parameters for functional safety and some grid code parameters are predefined and do not require any alteration during installation. However, some grid code parameters will require alterations during installation to allow optimisation of the local grid.

To meet these different requirements, the inverter is equipped with preset grid codes to accommodate standard settings. Since alteration of parameters can result in violation of legal requirements, as well as affect the grid negatively and reduce inverter yield, alterations are password-protected.

Depending on parameter type, some alterations are restricted to factory changes. In case of parameters used for optimisation of the local grid, alterations are allowed for installers. Alterations of parameters will automatically alter the grid code to “Custom”.

## 3.2 Change Procedure

Follow the procedure described below for each change of grid code, either directly or via changes to other functional safety settings. For more information, refer to International Inverter.

Procedure for PV plant owner

1. Determine the desired grid code setting. The person responsible for the decision to change the grid code accepts full responsibility for any future conflicts.
2. Order the change of setting with the authorised technician.

Procedure for authorised technician

1. Contact the service hotline to obtain a 24-hour level 2 password and username.
2. Access and change the grid code setting via the web interface or the display.
   - To change settings via the web interface/service interface, use remote access [Inverter level: Setup → Communication → Remote access].
   - The inverter logs the parameter change.
3. Complete and sign the form ‘Change of Functional Safety Parameters’.
   - For access via web server

     Generate a settings report.

     Fill out the form generated by the web interface on the PC.
4. Send the following to the DNO:
   - The form ‘Change of Functional Safety Parameters’, completed and signed.
   - Letter requesting copy of authorisation to be sent to the PV plant owner.

# 4 Requirements for Connection

## 4.1 Pre-installation Guidelines

Read this chapter before designing the PV system. It provides information required for planning integration of TLX Series inverters into a PV system:

- AC grid connection requirements, including choice of AC cable protection
- PV system design, including earthing
- Ambient conditions, such as ventilation

## 4.2 Requirements for AC Connection

**CAUTION**

**Always follow local rules and regulations.**

**⚠CAUTION**

**Prevent the system from reconnecting; secure the work area by marking, closing or locking off the area. Unintentional reconnection may result in severe accidents.**

**⚠CAUTION**

**Cover up all voltage-carrying system components that may cause personal injury while working. Make sure that danger areas are clearly marked.**

The inverters are designed with a three-phased, neutral and protective earth AC grid interface for operation under the following conditions:

| Parameter | Nominal | Min. | Max. |
|---|---|---|---|
| Grid voltage, phase – neutral | 230 V 20% | 184 V | 276 V |
| Grid frequency | 50 Hz 5% | 45 Hz | 55 Hz |

**Table 4.1 AC Operating Conditions**

When choosing grid code, the parameters in the above specification will be limited to comply with the specific grid codes.

**Earthing systems**

The inverters can operate on TN-S, TN-C, TN-C-S and TT systems.

**NOTE**

**Where an external RCD is required in addition to the built-in RCMU, a 300 mA RCD type B must be used to avoid tripping. IT systems are not supported.**

**NOTE**

**When using TN-C earthing to avoid earth currents in the communication cable, ensure identical earthing potential of all inverters.**

### 4.2.1 Mains Circuit Breaker, Cable Fuse and Load Switch

No consumer load should be applied between the mains circuit breaker and the inverter. An overload of the cable may not be recognised by the cable fuse, see *2.3.1 Functional Overview*. Always use separate fuses for consumer loads. Use dedicated circuit breakers with load switch functionality for load switching. Threaded fuse elements like 'Diazed' and 'Neozed' are not considered adequate as a load switch. Fuse holder may be damaged if dismounted under load. Use the PV load switch to turn off the inverter before removing/replacing the fuse elements. The selection of the mains circuit breaker rating depends on the wiring design (wire cross-sectional area), cable type, wiring method, ambient temperature, inverter current rating etc. Derating of the circuit breaker rating may be necessary due to self-heating or if exposed to heat. The maximum output current per phase can be found *Table 4.2*.

| | TLX Series | | | | |
|---|---|---|---|---|---|
| | 6k | 8k | 10k | 12.5k | 15k |
| Maximum inverter current, $I_{acmax.}$ | 9.0 A | 11.9 A | 14.9 A | 18.7 A | 22.4 A |
| Recommended blow fuse type gL/gG | 13 A | 16 A | 20 A | 20 A | 25 A |
| Recommended automatic fuse type B | 16 A | 20 A | 20 A | 25 A | 32 A |

**Table 4.2 Mains Circuit Specifications**

| Cable | Condition | Specification |
|---|---|---|
| **AC** | **5 wire cable** | **Copper** |
| Outer diameter | | 18-25 mm |
| Max. recommended cable length TLX Series 6k, 8k and 10k | 2.5 $mm^2$ | 21 m |
| | 4 $mm^2$ | 34 m |
| | 6 $mm^2$ | 52 m |
| | 10 $mm^2$ | 87 m |
| Max. recommended cable length TLX Series 12.5k | 4 $mm^2$ | 28 m |
| | 6 $mm^2$ | 41 m |
| | 10 $mm^2$ | 69 m |
| Max. recommended cable length TLX Series 15k | 6 $mm^2$ | 34 m |
| | 10 $mm^2$ | 59 m |
| **DC** | | **Max. 1000 V, 12 A** |
| Cable length | 4 $mm^2$ - 4.8 Ω /km | < 200 m* |
| Cable length | 6 $mm^2$ - 3.4 Ω /km | >200-300 m* |
| Mating connector | Multi-contact | PV-ADSP4./PV-ADBP4. |
| * The distance between inverter and PV array and back, plus the cumulative length of PV array cabling. | | |

**Table 4.3 Cable Requirements**

4

## NOTE

**Avoid power loss in cables greater than 1% of nominal inverter rating.**

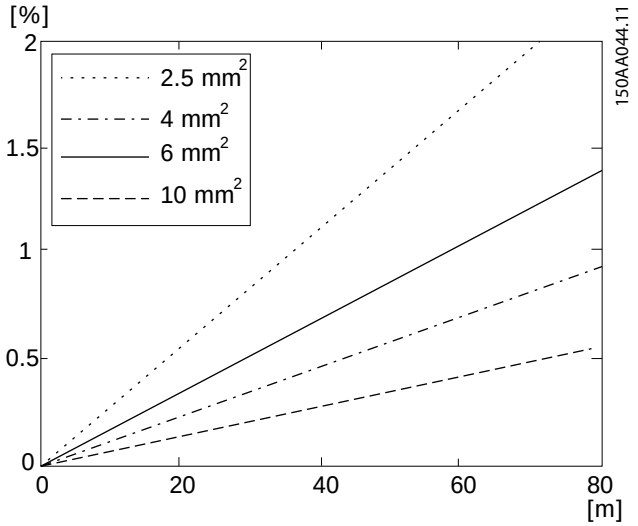


**Illustration 4.1 TLX Series 6k Cable Losses [%] versus Cable Length [m]**

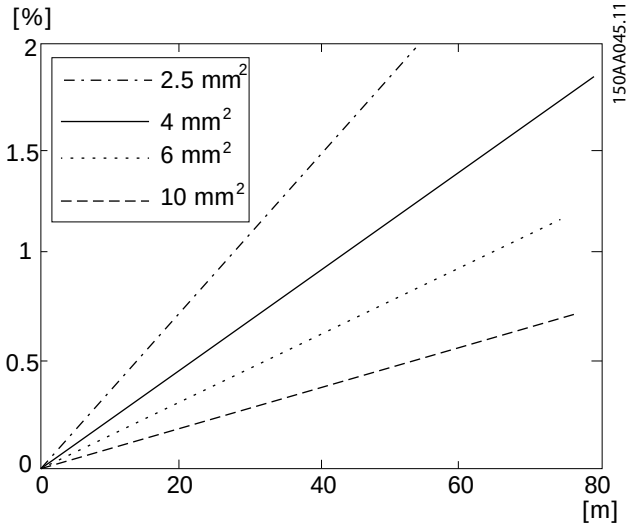


Illustration 4.2 TLX Series 8k Cable Losses [%] versus Cable Length [m]

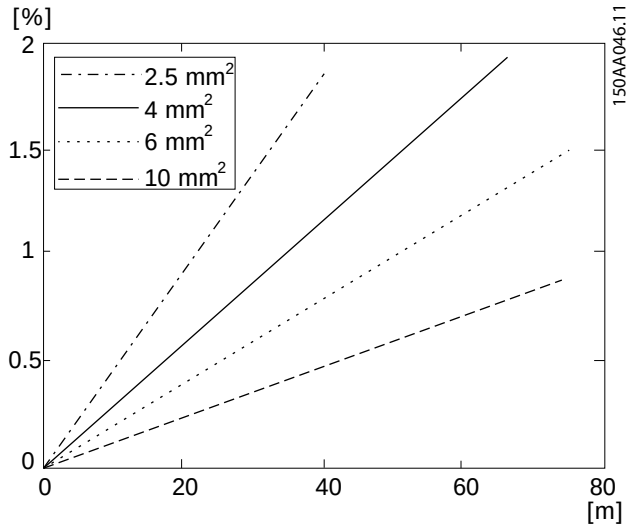


Illustration 4.3 TLX Series 10k Cable Losses [%] versus Cable Length [m]

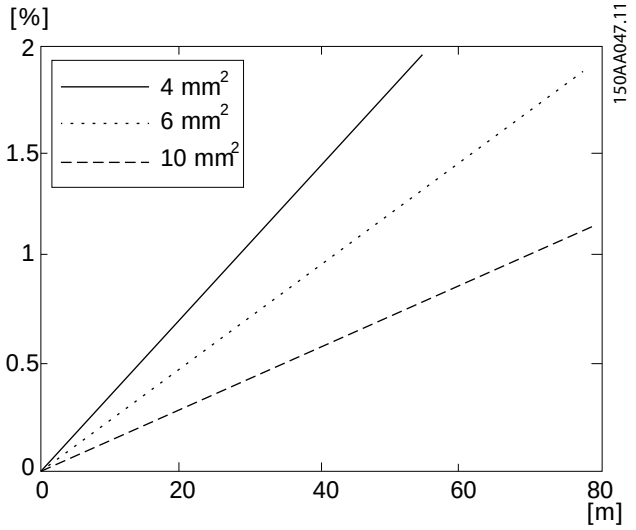


**Illustration 4.4 TLX Series 12.5k Cable Losses [%] versus Cable Length [m]**

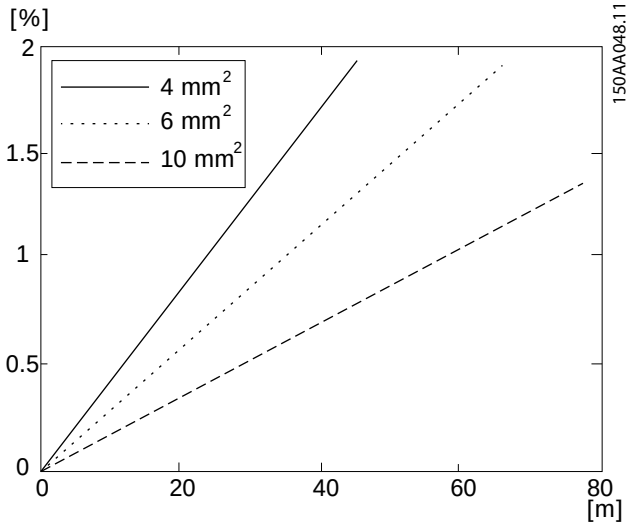


**Illustration 4.5 TLX Series 15k Cable Losses [%] versus Cable Length [m]**

Consider also the following when choosing cable type and cross-sectional area:

- Ambient temperature
- Layout type (inside wall, under ground, free air etc.)
- UV resistance

## 4.2.2 Grid Impedance

The grid impedance must correspond to the specifications to avoid unintended disconnection from the grid or derating of the output power. It is similarly important that proper cable dimensions are used to avoid losses. Additionally the no load voltage at the connection point must be taken into account. The maximum permitted grid impedance, as function of no load voltage for the TLX Series inverters, is shown in the following graph.

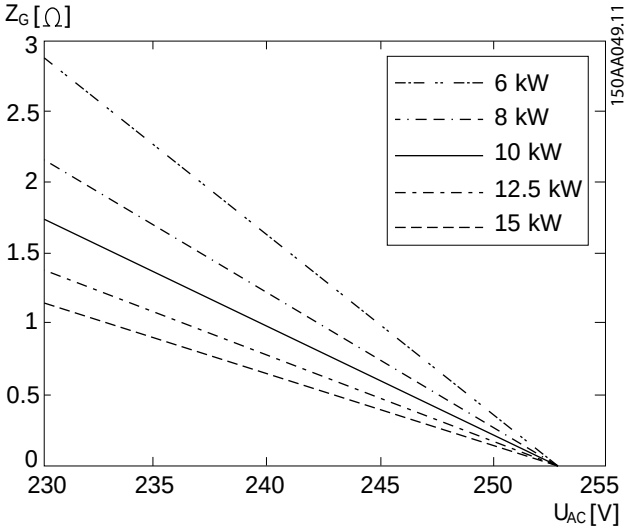


**Illustration 4.6 Grid impedance: Maximum permissible grid impedance [Ω] versus No load grid voltage [V]**



## 4.3 Requirements for PV Connection

The nominal/maximum input specification per PV input and total is shown in *Table 4.4*.
To avoid damaging the inverter, the limits in the table must be observed when dimensioning the PV generator for the inverter.

For guidance and recommendations on dimensioning the PV generator (module array), to align with the following inverter capability, refer to *4.3.1 Recommendations and Goals when Dimensioning*.

| Parameter | TLX Series | | | | |
|---|---|---|---|---|---|
| | 6k | 8k | 10k | 12.5k | 15k |
| Number of PV inputs | 2 | | | 3 | |
| Maximum input voltage, open circuit ($V_{dcmax}$) | 1000 V | | | | |
| Minimum MPP voltage ($V_{mppmin}$) | 250 V | | | | |
| Maximum MPP voltage ($V_{mppmax}$) | 800 V | | | | |
| Max./nom. input current ($I_{dcmax}$) | 12 A | | | | |
| Maximum short-circuit current ($I_{sc}$) | 12 A | | | | |
| Maximum PV input power per MPPT ($P_{mpptmax}$) | 8000 W | | | | |
| Max./nom. converted PV input power, total ($\Sigma P_{mpptmax}$) | 6200 W | 8250 W | 10300 W | 12900 W | 15500 W |

**Table 4.4 PV Operating Conditions**

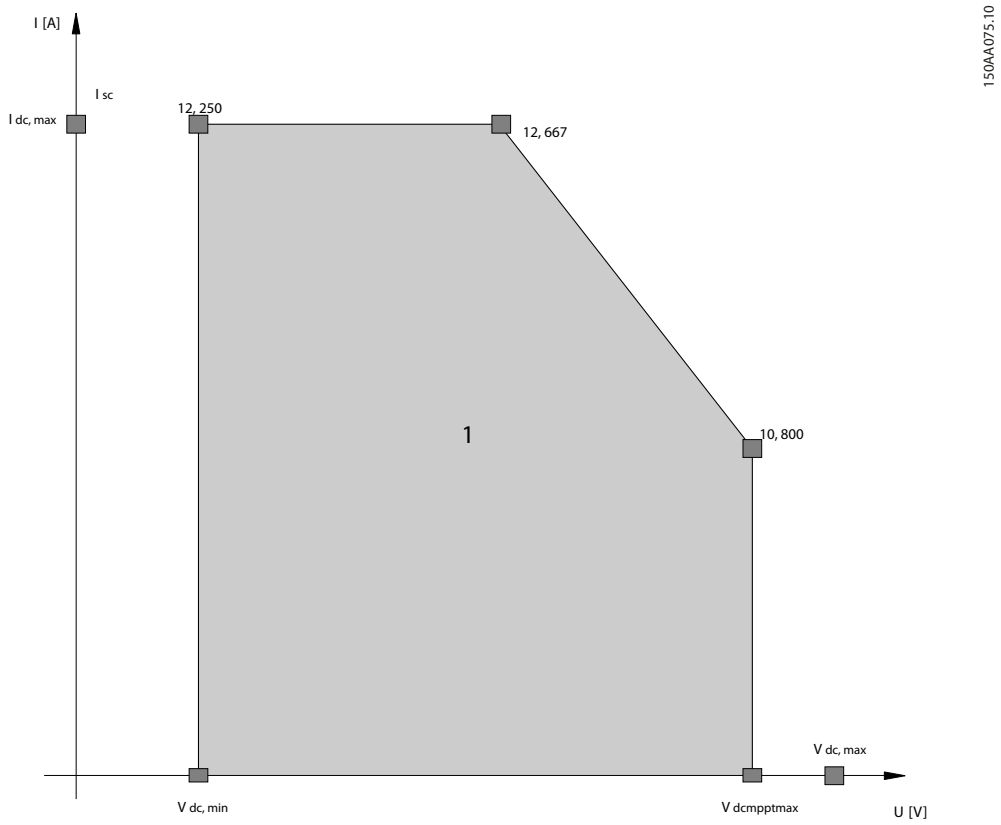


Illustration 4.7 Operating Range per MPP Tracker

| | |
|---|---|
| 1 | Operating Range per MPP Tracker |

Table 4.5 Legend to *Illustration 4.7*

### Maximum Open-circuit Voltage

The open-circuit voltage from the PV strings must not exceed the maximum open-circuit voltage limit of the inverter. Check the specification of the open-circuit voltage at the lowest PV module operating temperature. Also check that the maximum system voltage of the PV modules is not exceeded. During installation, verify the voltage before connecting the PV modules to the inverter; use a category III voltmeter that can measure DC values up to 1000 V.
Special requirements apply to thin film modules. See *4.3.2 Thin Film*.

### MPP Voltage

The string MPP voltage must be within the operational range of the MPPT of the inverter, defined by minimum voltage operation MPP (250 V) and maximum voltage operating MPP (800 V), for the temperature range of the PV modules.

### Short-circuit Current

The maximum short-circuit current ($I_{sc}$) must not exceed the absolute maximum that the inverter is able to withstand. Check the specification of the short-circuit current at the highest PV module operating temperature.

Observe the power limits for individual PV inputs. However, the converted input power will be limited by maximum converted PV input power, total ($\Sigma_{mpptmax}$) and not the sum of maximum PV input power per MPPT ($P_{mpptmax1} + P_{mpptmax2} + P_{mpptmax3}$).

### Max./Nom. Converted PV Input Power, Total

The 2 and/or 3 MPP trackers can handle more power in total than the inverter can convert. The inverter will limit the power intake by shifting the MPP when surplus PV power is available.

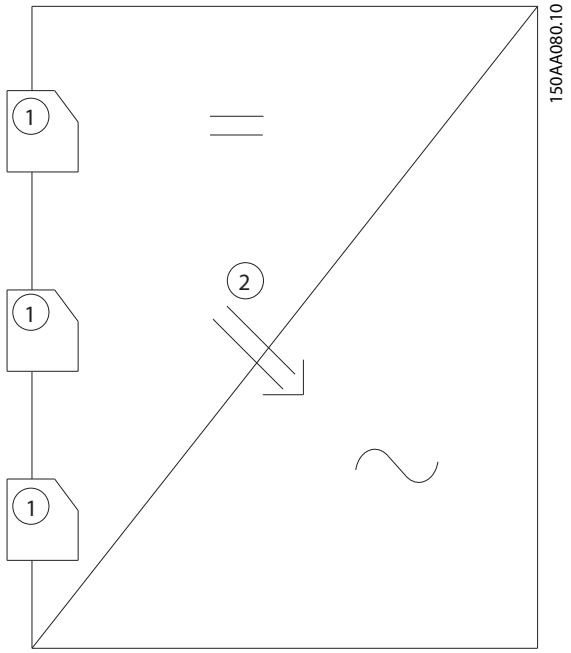


Illustration 4.8 Max./Nom. Converted PV Input Power, Total

| | |
|---|---|
| 1 | Operating range for each individual MPP tracker. |
| 2 | $\Sigma_{mpptmax}$, converted |

Table 4.6 Legend to *Illustration 4.8*

### Reversed Polarity

The inverter is protected against reversed polarity and will not generate power until the polarity is correct. Reversed polarity damages neither the inverter nor the connectors.

# CAUTION

**Remember to disconnect the PV load switch before correcting polarity!**

### PV to Earth Resistance

Monitoring of the PV to earth resistance is implemented for all grid codes, as supplying energy to the grid with too low a resistance could be harmful to the inverter and/or the PV modules. According to the German VDE0126-1-1 standard, the minimum resistance between the terminals of the PV arrays and earth must be 1 k Ω / $V_{OC}$, thus for a 1000 V system this corresponds to a minimum resistance of 1 MΩ. However, PV modules designed according to the IEC61215 standard are only tested to a specific resistance of minimum 40 MΩ*m$^2$. Therefore, for a 15 kW power plant with a 10% PV module efficiency, the total area of the modules yields 150 m$^2$, which again yields a minimum resistance of 40 MΩ*m$^2$/150 m$^2$=267 kΩ.
The required limit of 1 MΩ has for that reason been lowered to 200 kΩ (+ 200 kΩ to allow for for measuring inaccuracy), with the approval of the German authorities (Deutsche Gesetzliche Unfallsversicherung, Fachhausschuss Elektrotechnik).
During installation, the resistance must be verified before connecting the PV modules to the inverter. The procedure for verifying the resistance is found in the section on *PV Connection*.

### Earthing

It is not possible to earth any of the terminals of the PV arrays. However, it is compulsory to earth all conductive materials, e.g. the mounting system to comply with the general codes for electrical installations.

### Parallel Connection of PV Arrays

The PV inputs of the inverter can be internally (or externally) connected in parallel. See *Table 4.7*. The advantages and disadvantages of parallel connection are:

- **Advantages**
  - Layout flexibility
  - Parallel connection makes it possible to apply a single two-wire cable from the PV array to the inverter (reduces the installation cost)
- **Disadvantages**
  - Monitoring of each individual string is not possible
  - String fuses/string diodes may be necessary

After making the physical connection, the inverter carries out an autotest of the configuration and configures itself accordingly.

Examples of different PV connections/systems are illustrated with the explanatory overview in *Table 4.7*.

| Example | String capacity, orientation and inclination | Connection point | | B External splitter * | External parallel connection | C Internal parallel connection in inverter | Inverter inputs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | A Generator connection box | Inverter | | | | 1 | 2 | 3 |
| 1 | 3 identical | x | | Yes | 3 in parallel | Required | Splitter output (optional) | Splitter output | Splitter output |
| 2 | 3 identical | | x | | | Optional | 1 string | 1 string | 1 string |
| 3 | 3 different | | x | | | Not permitted | 1 string | 1 string | 1 string |
| 4 | 1 different<br>2 identical | | x | | | Not permitted for string 1.<br>Optional for strings 2 and 3. | 1 string | 1 string | 1 string |
| 5 | 4 identical | x | | Yes | 4 in parallel | Required | Splitter output (optional) | Splitter output | Splitter output |
| 6 | 4 identical | x | x | Yes | 3 in parallel<br>1 in series | Optional | | Splitter output | Splitter output |
| 7 | 6 identical | | x | | | Required | 2 strings | 2 strings | 2 strings |
| 8 | 4 identical | x | x | | | Required | 2 strings via Y-connector | 1 string | 1 string |

**Table 4.7 Overview of PV System Examples**

** When total input current exceeds 12 A, external splitter is required.*

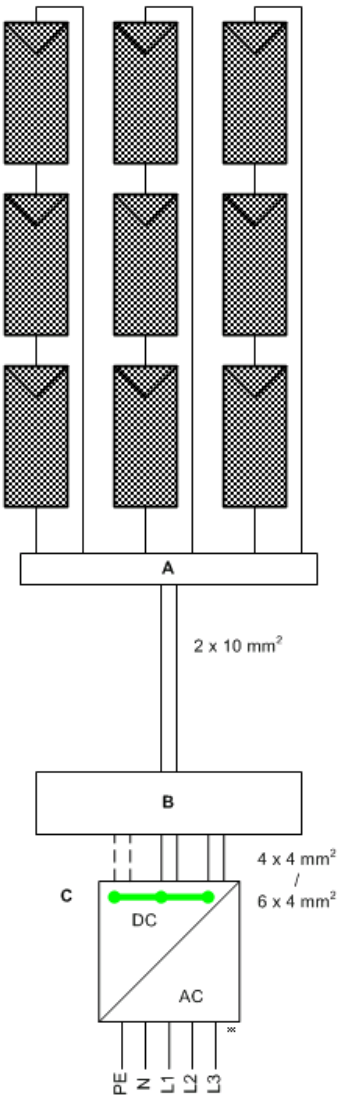


Illustration 4.9 PV System Example 1

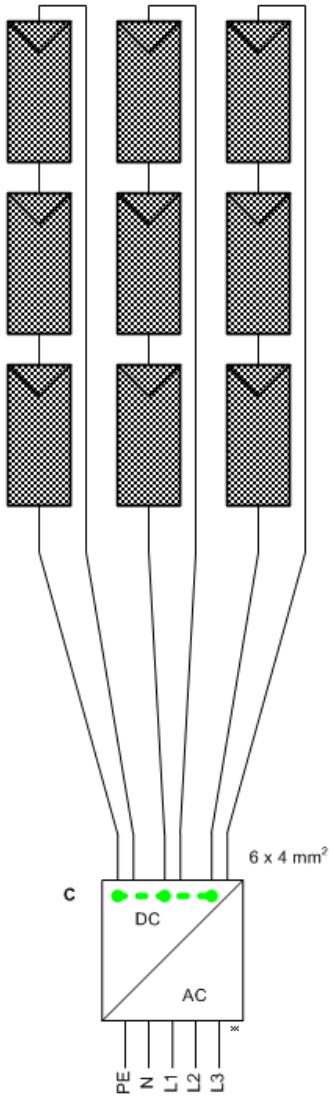


Illustration 4.9 PV System Example 2

Table 4.8 PV System Examples 1-2

| Example | String capacity, orientation and inclination | Connection point | | **B** External splitter * | External parallel connection | **C** Internal parallel connection in inverter | Inverter inputs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **A** Generator connection box | Inverter | | | | 1 | 2 | 3 |
| 1 | 3 identical | x | | Yes | 3 in parallel | Required | Splitter output (optional) | Splitter output | Splitter output |
| 2 | 3 identical | | x | | | Optional | 1 string | 1 string | 1 string |

Table 4.9 Legend to *Table 4.8*

** When total input current exceeds 12 A, external splitter is required.*

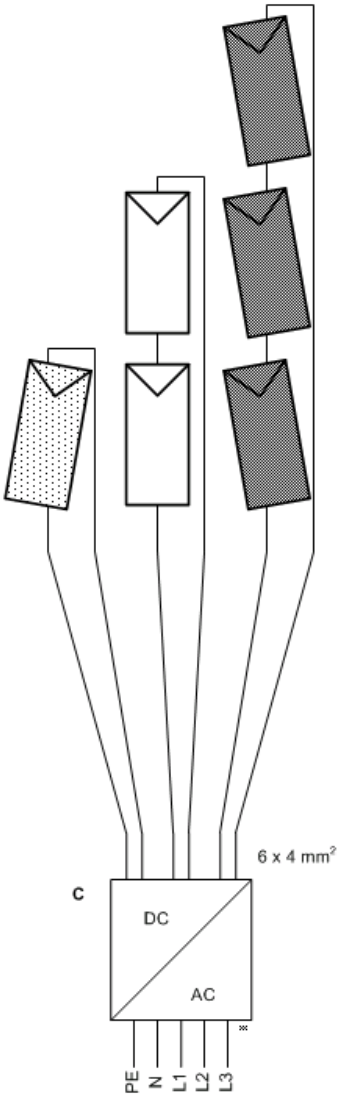


Illustration 4.9 PV System Example 3

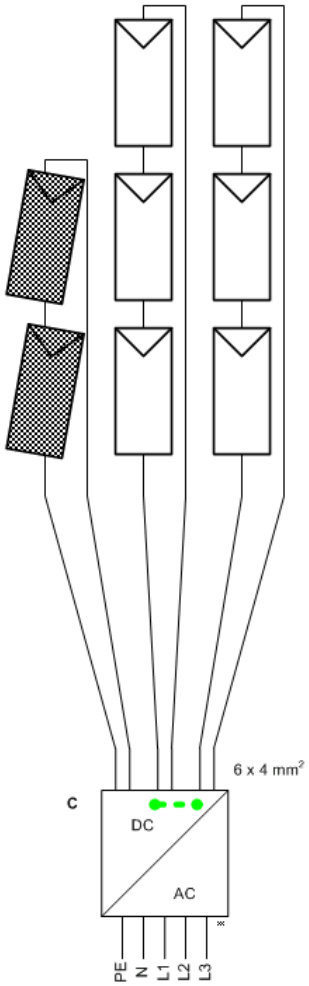


Illustration 4.9 PV System Example 4

Table 4.10 PV System Examples 3-4

| Example | String capacity, orientation and inclination | Connection point | | B External splitter * | External parallel connection | C Internal parallel connection in inverter | Inverter inputs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | A Generator connection box | Inverter | | | | 1 | 2 | 3 |
| 3 | 3 different | | x | | | Not permitted | 1 string | 1 string | 1 string |
| 4 | 1 different<br>2 identical | | x | | | Not permitted for string 1. Optional for strings 2 and 3. | 1 string | 1 string | 1 string |

Table 4.11 Legend to *Table 4.10*

** When total input current exceeds 12 A, external splitter is required.*

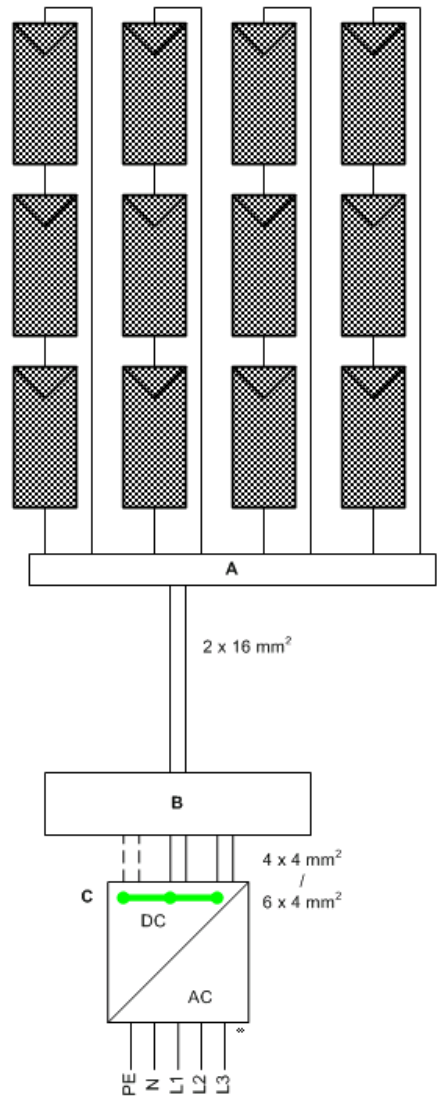


Illustration 4.9 PV System Example 5

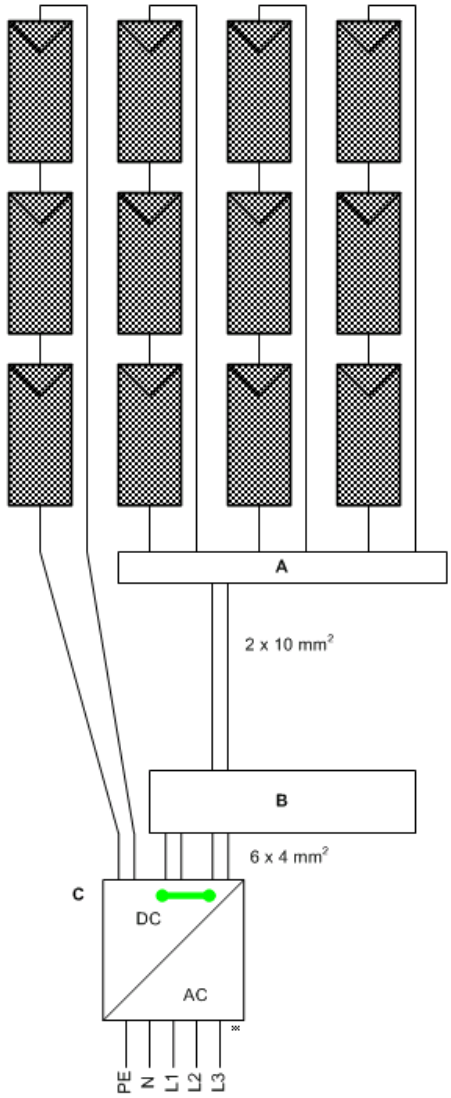


Illustration 4.9 PV System Example 6

Table 4.12 PV System Examples 5-6

| Example | String capacity, orientation and inclination | Connection point | | **B** External splitter * | External parallel connection | **C** Internal parallel connection in inverter | Inverter inputs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **A** Generator connection box | Inverter | | | | 1 | 2 | 3 |
| 5 | 4 identical | x | | Yes | 4 in parallel | Required | Splitter output (optional) | Splitter output | Splitter output |
| 6 | 4 identical | x | x | Yes | 3 in parallel 1 in series | Optional | | Splitter output | Splitter output |

Table 4.13 Legend to *Table 4.12*

** When total input current exceeds 12 A, external splitter is required.*

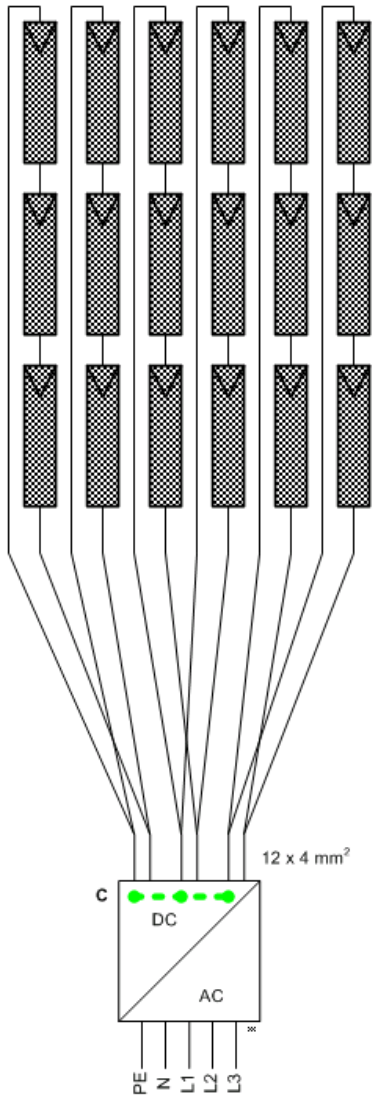


Illustration 4.9 PV System Example 7

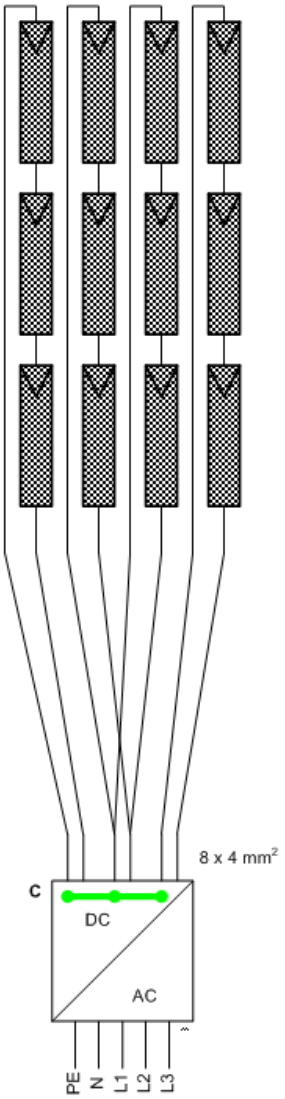


Illustration 4.9 PV System Example 8

Table 4.14 PV System Examples 7-8

| Example | String capacity, orientation and inclination | Connection point | | B External splitter * | External parallel connection | C Internal parallel connection in inverter | Inverter inputs | | |
|---|---|---|---|---|---|---|---|---|---|
| | | A Generator connection box | Inverter | | | | 1 | 2 | 3 |
| 7 | 6 identical | | x | | | Required | 2 strings | 2 strings | 2 strings |
| 8 | 4 identical | x | x | | | Required | 2 strings via Y-connector | 1 string | 1 string |

Table 4.15 Legend to *Table 4.14*

** When total input current exceeds 12A, external splitter is required.*

**PV Cable Dimensions and Layout**

The power loss in the PV cables should not exceed 1% of nominal value in order to avoid losses. For an array of 5000 W at 700 V, this corresponds to a maximum resistance of 0.98 Ω. Assuming aluminium cable is used (4 $mm^2$ → 4.8 Ω/km, 6 $mm^2$ → 3.4 Ω / km), the maximum length for a 4 $mm^2$ cable is approximately 200 m and for a 6 $mm^2$ cable approximately 300 m. The total length is defined as twice the physical distance between the inverter and the PV array plus the length of the PV cables included in the modules. Avoid looping the DC cables as they can act as an antenna of radio-noise emitted by the inverter. Cables with positive and negative polarity should be placed side by side with as little space between them as possible. This also lowers the induced voltage in case of lightning and reduces the risk of damage.

| DC | | Max. 1000 V, 12 A |
|---|---|---|
| Cable length | 4 $mm^2$ -4.8 Ω /km | <200 m* |
| Cable length | 6 $mm^2$ -3.4 Ω /km | >200-300 m* |

**Table 4.16 Cable Specifications**

** The distance between inverter and PV array and back, plus the cumulative length of PV array cabling.*

## 4.3.1 Recommendations and Goals when Dimensioning

**Optimising the PV Configuration: Voltage**

The output power from the inverter can be optimised by applying the maximum open circuit input voltage ($V_{dcmax}$) per input. The minimum limit for open-circuit voltage is 500 V.

Examples:

1. In a PV system of 75 modules, each with an open circuit voltage of 40 V at -10 °C and 1000 W/m2, it is possible to connect up to 25 modules in one string (25*40 V=1000 V). This allows for three strings and every string reaches the maximum inverter input voltage of 1000 V at -10 °C and 1000 W/$m^2$, similar to PV system examples 1 and 2.
2. Another PV system only has 70 modules of the same type as above. Thus only two strings can reach the optimum of 1000 V. The remaining 20 modules reach a voltage value of 800 V at -10 °C . This string should then be connected to the last inverter input, similar to PV system example 4.
3. Finally, a third PV system has 62 modules of the type described above. With two strings of 25 modules, 12 modules remain for the last inverter input. 12 modules only produce 480 V open circuit voltage at -10 °C. The voltage at the last inverter input is consequently too low. A correct solution is to connect 22 modules to the first inverter input and two times 20 modules to the remaining two inputs. This corresponds to 880 V and 800 V at -10 °C and 1000 W/$m^2$, similar to PV system example 4.

**Optimising PV Power**

The ratio between installed PV power at STC ($P_{STC}$) and nominal inverter power ($P_{NOM}$), the so-called PV-to-grid ratio $K_{PV-AC}$, is used to evaluate the sizing of the inverter. To reach a maximum Performance Ratio with a cost efficient solution the following upper limits should not be exceeded. The values in *Table 4.17* are for guidance only.

| | Corresponding power for inverter type | | | | | |
|---|---|---|---|---|---|---|
| | | TLX Series | | | | |
| System type | Max $K_{PV-AC}$ | 6k | 8k | 10k | 12.5k | 15k |
| Tracker systems | 1.05 | 6.3 kWp | 8.4 kWp | 10.5 kWp | 13.1 kWp | 15.7 kWp |
| Fixed systems with optimal conditions: Close to ideal orientation (between SW and SE) and inclination (more than 10°) | 1.12 | 6.7 kWp | 9.0 kWp | 11.2 kWp | 14.0 kWp | 16.8 kWp |
| Fixed systems with semi-optimal conditions: Orientation **or** inclination is outside the above mentioned limits. | 1.18 | 7.1 kWp | 9.4 kWp | 11.8 kWp | 14.7 kWp | 17.7 kWp |
| Fixed systems with sub-optimal conditions: Orientation **and** inclination is outside the above mentioned limits. | 1.25 | 8 kWp | 10.0 kWp | 12.5 kWp | 15.6 kWp | 18.7 kWp |

**Table 4.17 Optimisation of PV Configuration**

*According to Dr. B. Burger "Auslegung und Dimensionierung von Wechselrichtern für netzgekoppelte PV-Anlagen", Fraunhofer-Institut für Solare Energiesysteme ISE, 2005.*

## NOTE

**The data is only valid for northern European conditions (> 48° North). The PV-to-grid ratio is provided specifically for PV systems that are optimised with respect to inclination and orientation.**

**Design for Reactive Power**

The nominal active power (P) and the maximum apparent power (S) of the inverter are equal. Thus there is no overhead for producing reactive (Q) power at full active power. When the inverters are installed in a PV power plant, which has to generate a certain amount of reactive power, the amount of installed PV capacity per inverter must therefore be reduced.



Two cases must be expected:

1. A certain power factor (PF) is required, e.g. PF=0.95: thus the PV-to-grid ratio, $K_{PV-AC}$, should be multiplied with 0.95. The corrected ratio is then used for dimensioning the plant.
2. The DNO specifies a required amount of reactive power (Q), the nominal power (P) of the plant is known. The PF can then be calculated as: PF=SQRT($P^2$/(P^2+$Q^2$)). The PF is then applied as above.

**Design for Low AC Grid Voltage**

The nominal output power of the inverter is specified at a grid voltage of 230 V. The input power should be derated for an AC grid where the voltage is below this limit. Lower grid voltage may occur if the inverter is installed in a network placed at a distance from the transformer and/or with high local loads, for example in an industrial area. To ensure adequate AC grid voltage, measure the grid voltage at 10.00 am, 12.00 am and 2 pm, when the load and irradiance are high.

There are two alternatives:

1. Downsize the PV plant to:
   - $P_{STC}=P_{NOM} * K_{PV-AC}$ * measured grid voltage/230,
     where
     - $P_{STC}$ is the installed PV power at STC
     - $P_{NOM}$ is the nominal inverter power
     - $K_{PV-AC}$ is the so-called PV-to-grid ratio
2. Contact the local DNO to increase the limit on the transformer.

### 4.3.2 Thin Film

The use of TLX Series inverters with thin film modules has been approved by some manufacturers. Declarations and approvals can be found at www.danfoss.com/solar. If no declaration is available for the preferred module it is important to obtain approval from the module manufacturer before installing thin film modules with the inverters.
The power-circuit of the inverters is based on an inverted asymmetrical boost converter and bipolar DC-link. The negative potential between the PV arrays and earth is therefore considerably lower, compared to other transformerless inverters.

## CAUTION

**Module voltage during initial degradation may be higher than the rated voltage in the data sheet. This must be taken into consideration when designing the PV system, since excessive DC voltage can damage the inverter. Module current may also lie above the inverter current limit during the initial degradation. In this case the inverter decreases the output power accordingly, resulting in lower yield. Therefore when designing, take inverter and module specifications both before and after initial degradation into consideration.**

### 4.3.3 Overvoltage Protection

The inverter is manufactured with internal overvoltage protection on the AC and PV side. If the PV system is installed on a building with an existing lightning protection system, the PV system must also be properly included in the lightning protection system. The inverters are classified as having Type III (class D) protection (limited protection). Varistors in the inverter are connected between phase and neutral cables, and between PV plus and minus terminals. One varistor is positioned between the neutral and PE cables.

| Connection point | Overvoltage category according to EN50178 |
|---|---|
| AC side | Category III |
| PV side | Category II |

**Table 4.18 Overvoltage Category**

### 4.3.4 Thermal Management

All power electronics equipment generates waste heat, which must be controlled and removed to avoid damage and to achieve high reliability and long life. The temperature around critical components like the integrated power modules is continuously measured to protect the electronics against overheating. If the temperature exceeds

the limits, the inverter reduces input power to keep the temperature at a safe level.
The thermal management concept of the inverter is based on forced cooling by means of speed-controlled fans. The fans are electronically controlled and are only active when needed. The back side of the inverter is designed as a heatsink that removes the heat generated by the power semiconductors in the integrated power modules. Additionally, the magnetic parts are ventilated by force. At high altitudes, the cooling capacity of the air is reduced. The fan control will attempt to compensate for the reduced cooling. At altitudes higher than 1000 m, derating of the inverter power at system layout should be considered to avoid loss of energy.

| Altitude | 2000m | 3000m |
|---|---|---|
| Max. load of inverter | 95% | 85% |

**Table 4.19 Compensation for Altitude**

## NOTE

**PELV protection is effective up to 2000 m above sea level only.**

Other factors like higher irradiation should also be taken into account. The heatsink should be cleaned regularly and checked for dust and blocking elements once a year.

Optimise reliability and lifetime by mounting the inverter in a location with low ambient temperature.

## NOTE

**For calculation of ventilation, use maximum heat dissipation of 600 W per inverter.**

### 4.3.5 Simulation of PV

Contact the supplier before connecting the inverter to a power supply for testing purposes, e.g. simulation of PV. The inverter has built-in functionalities that may harm the power supply.

# 5 Installation and Start-up

## 5.1 Installation Dimensions and Patterns

Illustration 5.1 Avoid constant stream of water

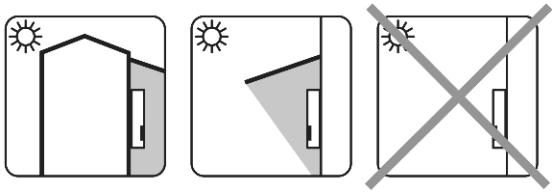

Illustration 5.2 Avoid direct sunlight

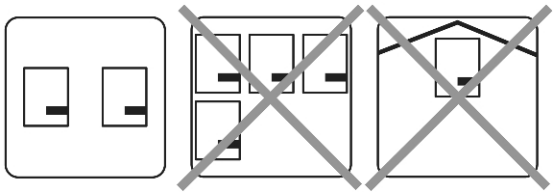

Illustration 5.3 Ensure adequate air flow

Illustration 5.4 Ensure adequate air flow

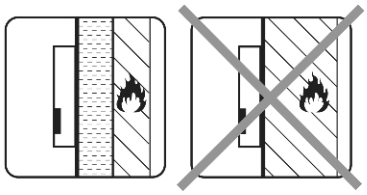

Illustration 5.5 Mount on non-flammable surface

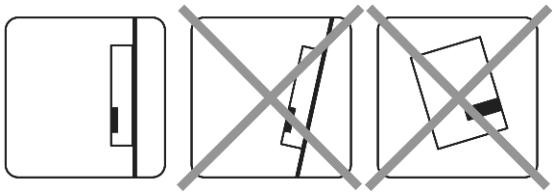

Illustration 5.6 Mount upright on vertical surface

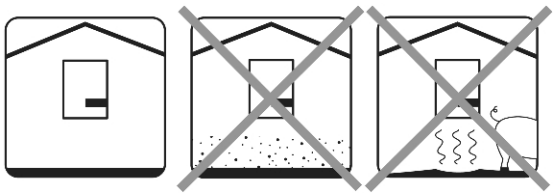

Illustration 5.7 Prevent dust and ammonia gases

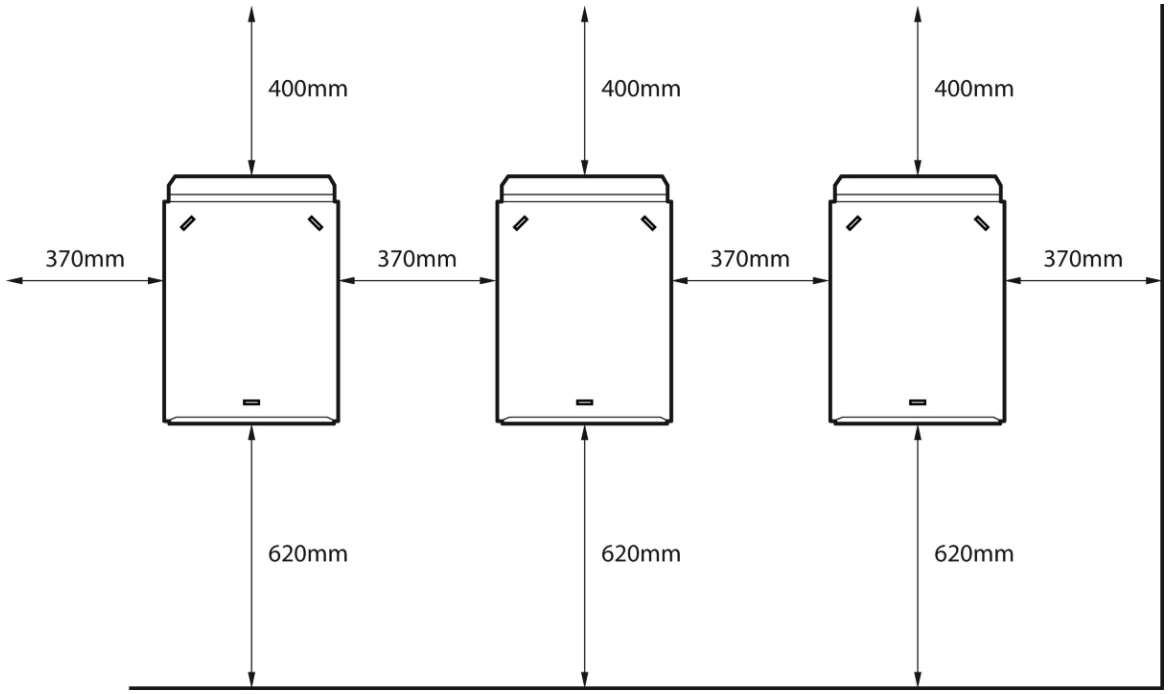


Illustration 5.8 Safe Distances

Observe these distances when installing one or more inverters. One-row mounting is recommended. Contact the supplier for information on mounting in more rows.

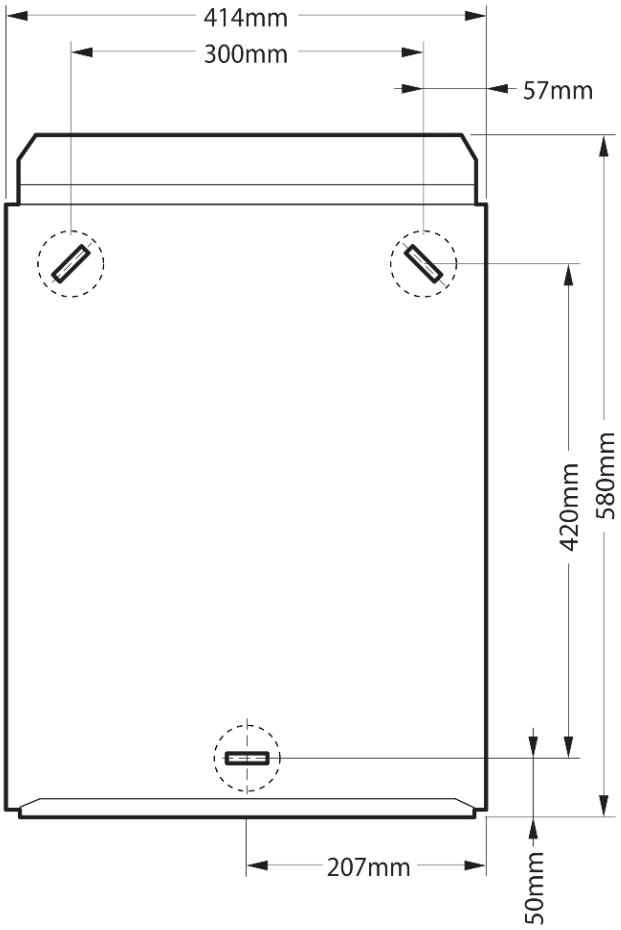


Illustration 5.9 Wall Plate

## NOTE

**Use of the wall plate delivered with the inverter is mandatory.**

Use screws that can safely carry the weight of the inverter. The inverter must be aligned and it is important that the inverter is accessible at the front to allow room for servicing.

## 5.2 Mounting the Inverter

**⚠CAUTION**

**For safe handling of the inverter, two people must carry the unit, or a suitable transport trolley must be used. Safety boots must be worn.**

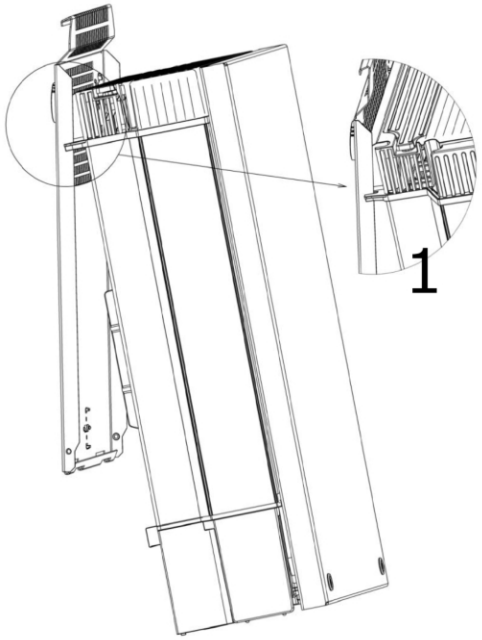


**Illustration 5.10 Position the Inverter**

Tilt the inverter as shown in the illustration and place the top of the inverter against the mounting bracket. Use the two guides (1) at the top plate to control the inverter horizontally.

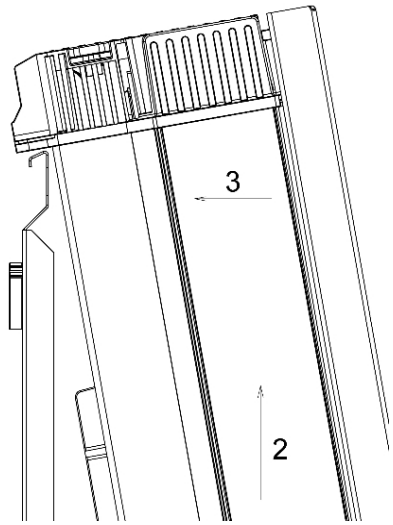


**Illustration 5.11 Secure the inverter**

Lift the inverter upwards (2) over the top of the mounting plate until the inverter tilts towards the wall (3).

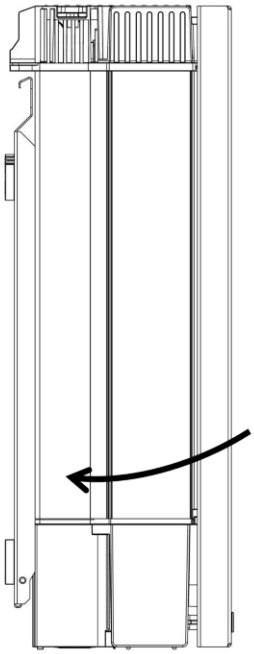

**Illustration 5.12 Place Inverter in Mounting Bracket**

Place the lower part of the inverter against the mounting bracket.

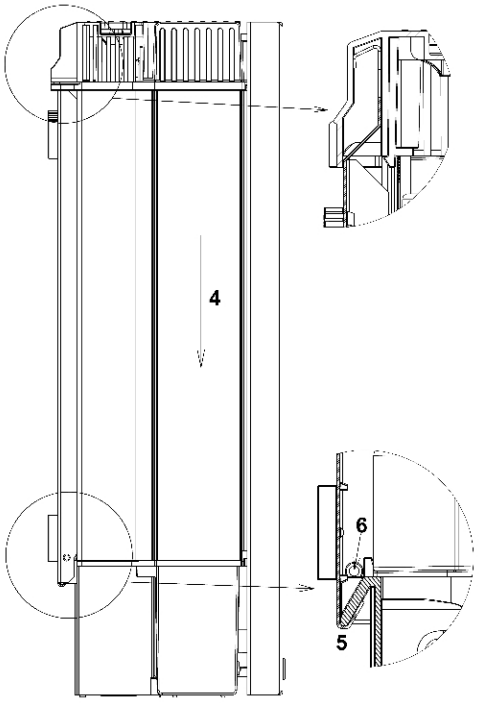


**Illustration 5.13 Fasten screws**

Lower (4) the inverter and make sure that the hook of the inverter base plate is placed in the lower part of the

mounting bracket (5). Check that it is not possible to lift the bottom of the inverter away from the mounting bracket. (6) Fasten the screws on either side of the wall plate to secure the inverter.

## 5.3 Removing the Inverter

Loosen the locking screws on either side of the inverter.

Removal is performed in the reverse order of mounting. With a firm grip at the lower end of the inverter, lift the inverter approximately 20 mm vertically. Pull the inverter slightly away from the wall. Push upwards at an angle until the wall plate releases the inverter. Lift the inverter away from the wall plate.

5

## 5.4 Opening and Closing the Inverter

**⚠WARNING**

**Remember to observe all ESD safety regulations. Any electrostatic charge must be discharged by touching the earthed housing before handling any electronic component.**

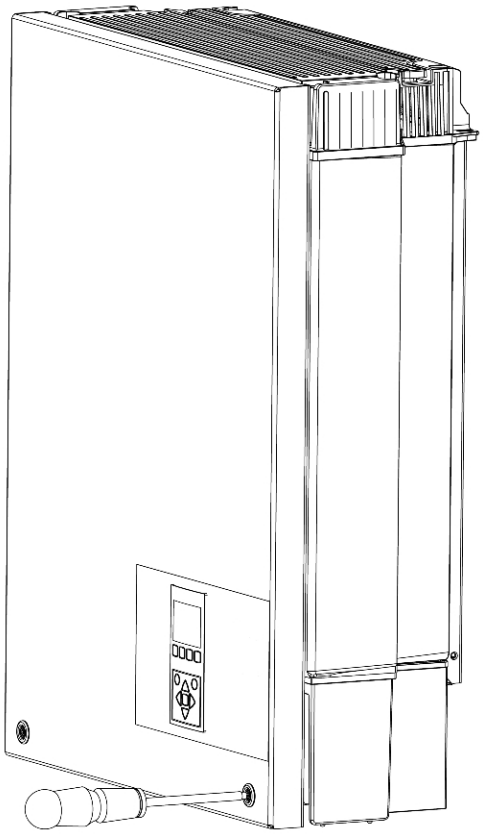

**Illustration 5.14 Loosen Front Screws**

Use a TX 30 screwdriver to loosen the two front screws. Turn the screwdriver until the screws pop up. Screws are secured with a spring and cannot fall out.

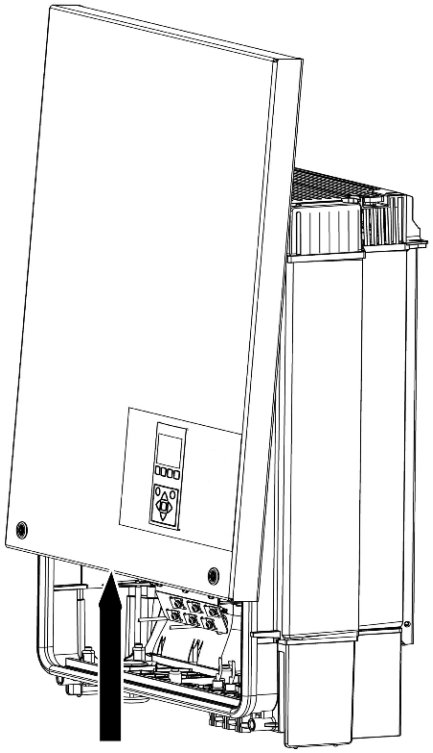

**Illustration 5.15 Open the Inverter**

Push the front cover upwards. When a slight resistance is felt, give the front cover a tap on the bottom to snap it into holding position. It is recommended to use the holding position instead of dismounting the front cover completely.

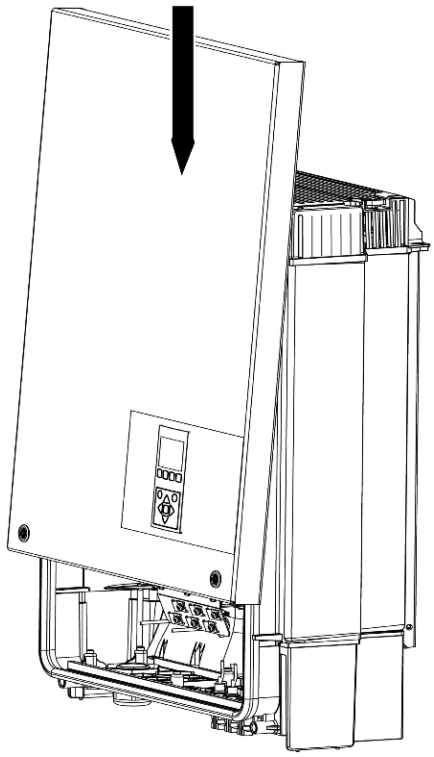

Illustration 5.16 Close the Inverter

To close the inverter, hold on to the lower end of the front cover with one hand and give it a tap on the top until it falls into place. Guide the front cover into place and fasten the two front screws.

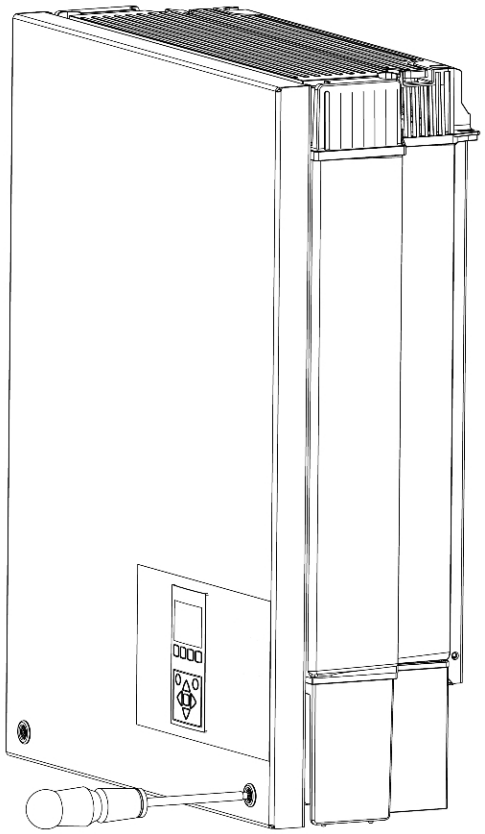

Illustration 5.17 Fasten Front Screws

**⚠CAUTION**

**The two front screws are the PE connection to the front cover. Make sure that both screws are mounted and fastened with the specified torque.**

## 5.5 AC Grid Connection

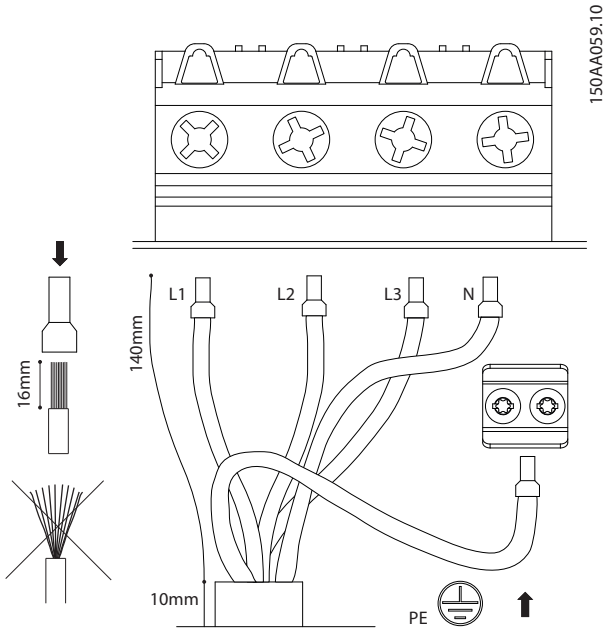


**Illustration 5.18 AC Cable Wire Strip**

The illustration shows the stripping of insulation of all 5 wires of the AC cable. The length of the PE wire must be longer than the mains and neutral wires.

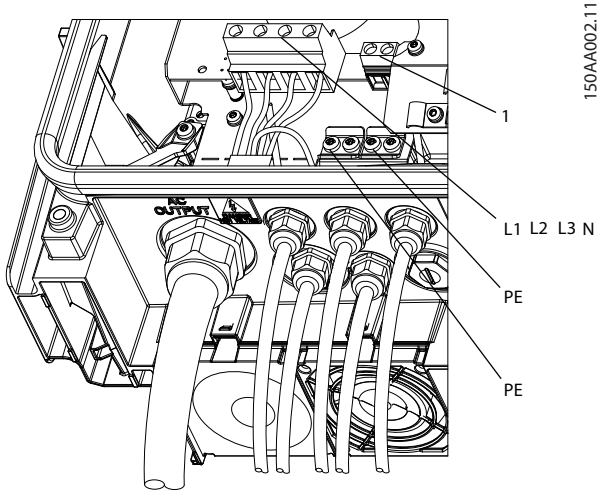


**Illustration 5.19 AC Connection Area**

| | |
|---|---|
| 1 | Short-circuit bridge |
| L1, L2, L3, N | 3 mains (L1, L2, L3) and neutral (N) terminals |
| PE | Protective earth wire |

**Table 5.1 Legend to *Illustration 5.19***

1. Verify the inverter matches the grid-voltage.
2. Release main circuit breaker and make precautions to prevent reconnection.
3. Open the front cover.
4. Insert the cable through the AC gland to the terminal blocks.
5. The three mains wires (L1, L2, L3) and the Neutral wire (N) are mandatory and must be connected to the 4-pole terminal block with the respective markings.
6. The Protective Earth wire (PE) is mandatory and must be connected directly to the chassis PE terminal. Insert the wire and fasten the screw to secure the wire.
7. All wires must be properly fastened with the correct torque. See *11.5 Torque Specifications for Installation*.
8. Close the front cover, and remember to verify that both front screws are applied with the correct torque (6-8 Nm) to obtain PE connection.
9. Close main circuit breaker.

# CAUTION

**For safety, check all wiring. Connecting a phase wire to the neutral terminal may permanently damage the inverter. Do not remove the short-circuit bridge at (1).**

## 5.6 Parallel PV String Configuration

For parallel PV string configuration, always use the internal parallel jumper, together with an external parallel coupling.

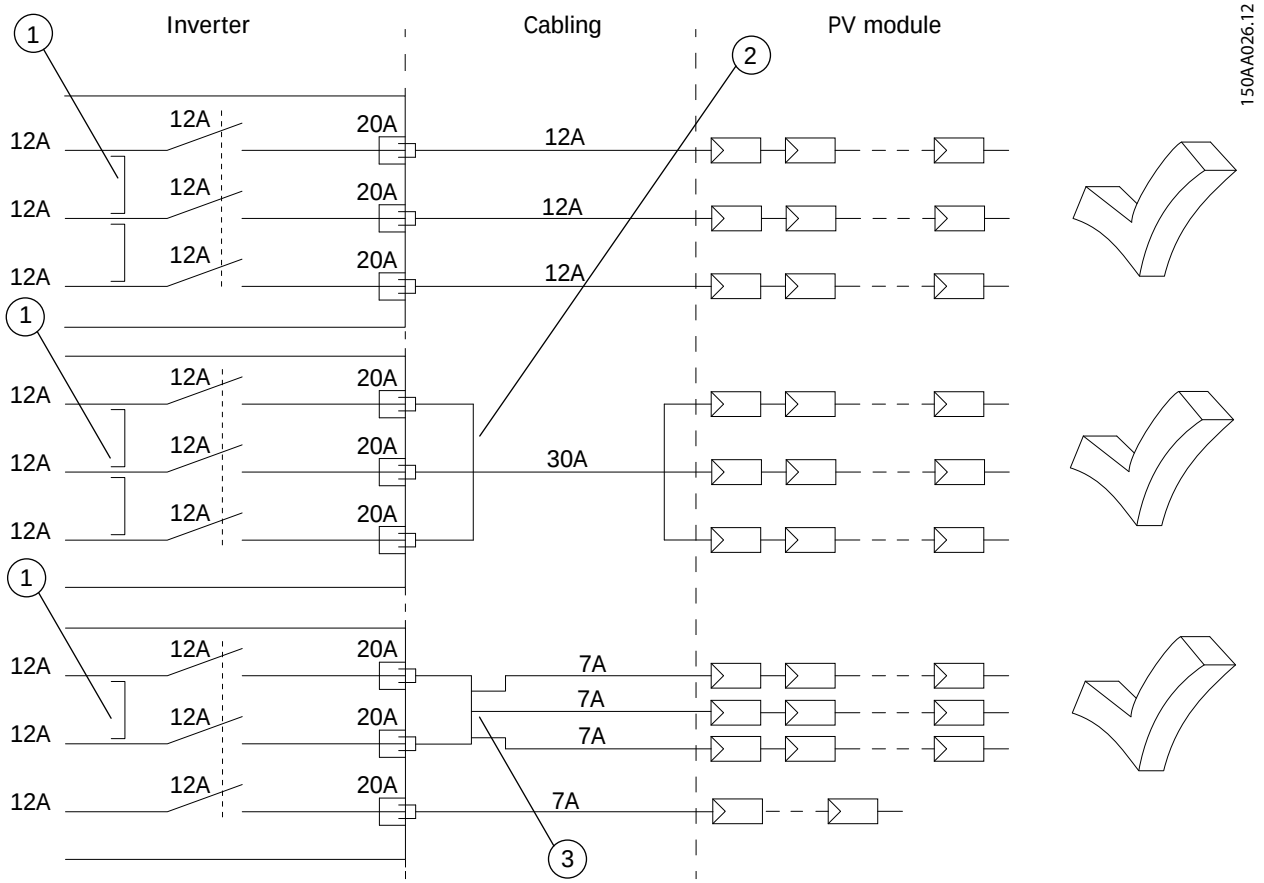


**Illustration 5.20 Correct Parallel Connection**

| | |
|---|---|
| 1 | Parallel jumper |
| 2 | Parallel connection, 3 inputs |
| 3 | Parallel connection, 2 inputs |

**Table 5.2 Legend to *Illustration 5.20***

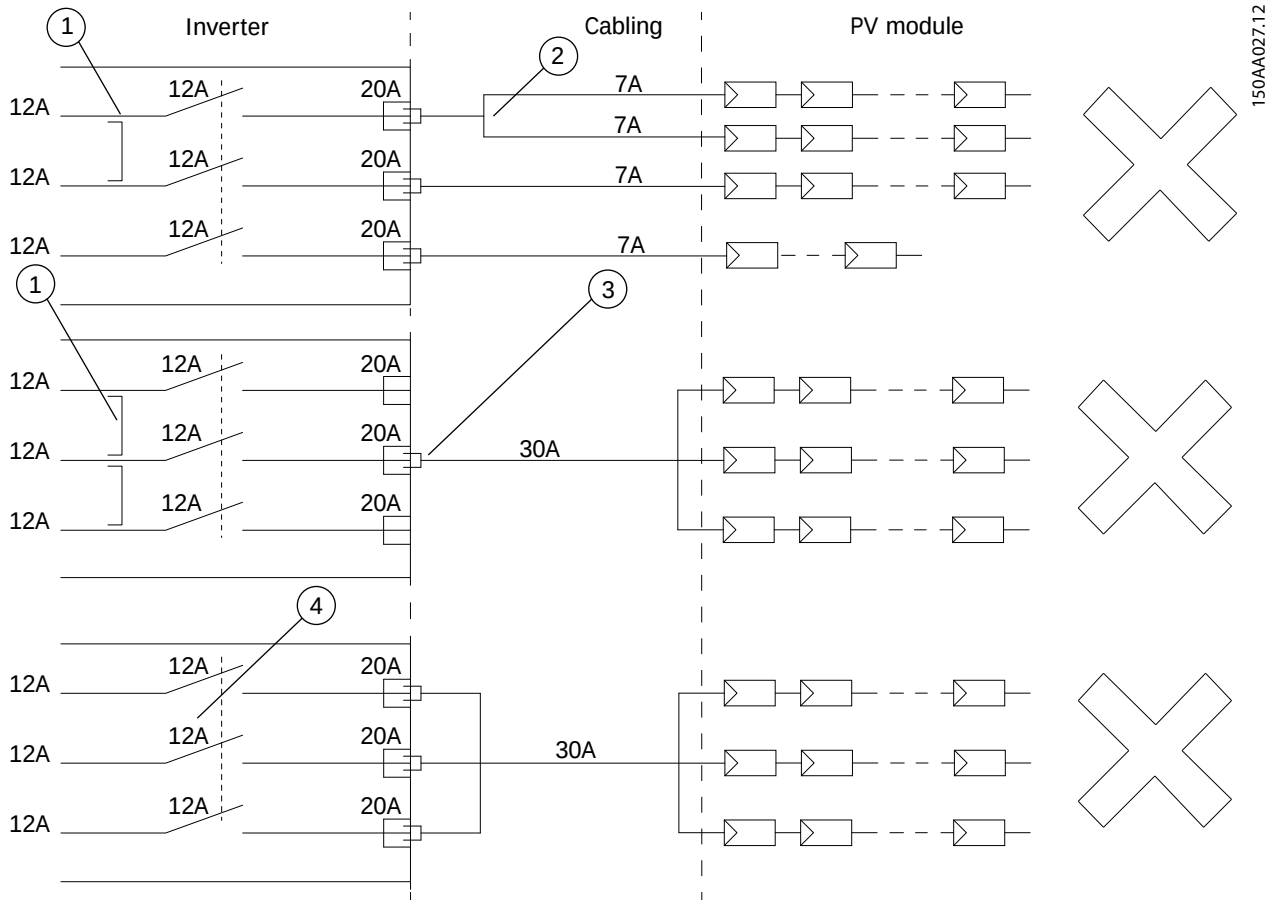


Illustration 5.21 Incorrect Parallel Connection

| | |
|---|---|
| 1 | Parallel jumper |
| 2 | Parallel connection, 1 input. Current in first input is exceeded, thus overloading cable and PV load switch. |
| 3 | Parallel connection missing. All PV power feeds into one input, thus risking overload of PV connector, cable and PV load switch. |
| 4 | Parallel jumper missing, thus risking overload of PV connector, cable and PV load switch in the event of inverter failure. |

Table 5.3 Legend to *Illustration 5.21*

## 5.7 PV Connection

**⚠WARNING**

**Do NOT connect PV to earth!**

**NOTE**

**Use a suitable voltmeter that can measure up to 1000 V DC.**

**PV Connection Procedure:**

1. First verify the polarity and maximum voltage of the PV arrays by measuring the PV open-circuit voltage. The PV open-circuit voltage must not exceed 1000 V DC.
2. Measure the DC voltage between the plus-terminal of the PV array and Earth (or the green/yellow PE cable). The voltage measured should approximate zero. If the voltage is constant and not zero there is an insulation failure somewhere in the PV array. Locate and fix the failure before continuing.
3. Repeat this procedure for all arrays. It is allowed to distribute the input power on the inputs unevenly, presuming that:
   - The nom. PV power of the inverter is not exceeded (6.2 / 8.2 / 10.3 / 12.9 / 15.5 kW).
   - The maximum short-circuit current of the PV modules must not exceed 12 A per input.
4. On the inverter turn the PV load switch into off position. Connect the PV cables by means of MC4 connectors. Ensure correct polarity! The PV load switch can now be switched on when required.

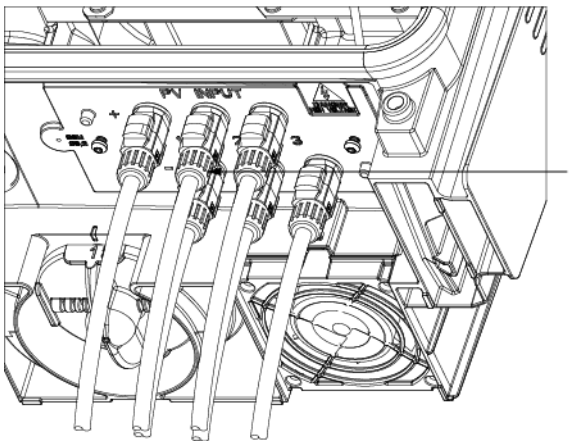


**Illustration 5.22 DC Connection Area**

**⚠CAUTION**

**When unmated, the MC4 connectors are not IP54. Intrusion of moisture may occur. In situations where the PV connectors are not fitted, a seal cap must be mounted (included in the scope of the delivery). All inverters with MC4 connections are delivered with seal caps on inputs 2 and 3. During installation, the seal caps of those inputs that are to be used are discarded.**

**NOTE**

**The inverter is protected against reversed polarity but it will not generate power until the polarity is corrected. To achieve optimum production, the open-circuit voltage (STC) of the PV modules must be lower than the max. input voltage of the inverter (see *11.1 General Data*), multiplied with a factor of 1.13. $U_{OC}$, STC x 1.13 ≤ $U_{MAX}$, inv.**

### 5.7.1 Manual PV Configuration

Set up the inverter for manual PV configuration at security level 1:

- via the display at [Setup → Setup details → PV configuration]
- via the web interface at [Inverter → Setup → Setup details → PV configuration]

The autodetection is subsequently overridden.

To set the configuration via the display manually:

1. Turn on AC to start the inverter.
2. Enter installer password (supplied by distributor) in the display setup menu. Go to [Setup → Security → Password].
3. Press Back and use the arrows to find the PV configuration menu under the menu setup details, go to [Setup → Setup details → PV configuration].
4. Select PV configuration mode. Make sure that the configuration that corresponds to the wiring is selected, go to [Setup → Setup details → PV configuration → Mode: Parallel].

# 6 Connection of Peripheral Units

## 6.1 Overview

**CAUTION**

**Auxiliary interfaces are provided via PELV circuits and are safe to touch during normal operation. AC and PV must, however, be turned off before installation of peripheral units.**

**NOTE**

**For wiring details, refer to *11.7 Auxiliary Interface Specifications*.**

6

The inverter has the following auxiliary input/output:

**Communication interfaces**

- GSM modem
- RS-485 communication **(1)**
- Ethernet communication **(2)**:
  - all TLX variants: service web interface
  - TLX Pro and TLX Pro+ variants only - web interface functionality

**Sensor inputs (3)**

- PT1000 temperature sensor input x 3
- Irradiation sensor input
- Energy meter (S0) input

**Alarm Output (4)**

- Potential free relay output

Except for the GSM modem, which has an externally mounted antenna, all auxiliary interfaces are located internally in the inverter. For setup instructions, refer to *7 User Interface* , or see the *Web Server User Manual*.

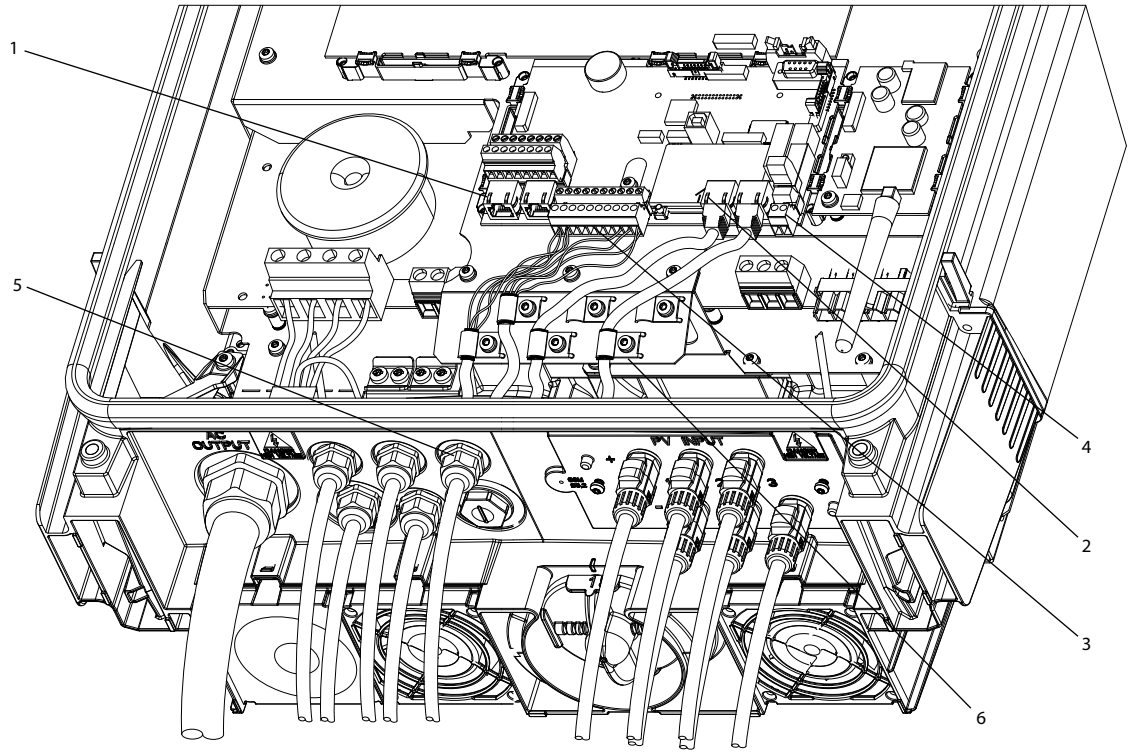


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**Illustration 6.1 Auxiliary Connection Area**

| | |
|---|---|
| 1-4 | Communication board |
| 5 | Cable glands |
| 6 | EMC clamps |

**Table 6.1 Legend to *Illustration 6.1***

## 6.2 Installation of Peripheral Cables

**⚠CAUTION**

**To ensure fulfilment of the IP enclosure rating, correctly mounted cable glands are essential for all peripheral cables.**

**Hole for cable gland**

The base plate of the inverter is prepared for cable glands M16 (6 pcs.) and M25 (2 pcs.). Holes and threads are pre-drilled and shipped with blind plugs.

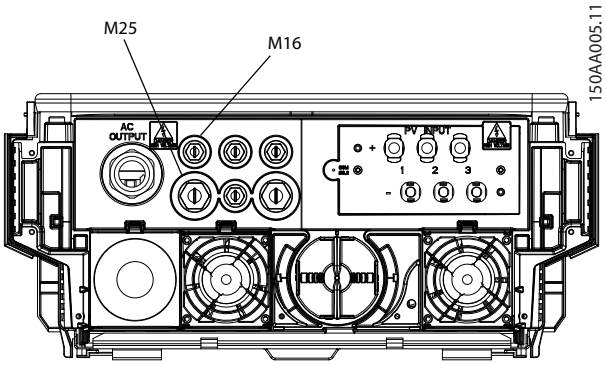


**Illustration 6.2 Auxiliary Connection Area, Cable Glands 2 x M25 and 6 x M16.**

| | |
|---|---|
| M25 | For RS-485 and Ethernet peripheral units which apply RJ-45 plugs. |
| M16 | Other peripheral units (sensors, alarm outputs and RS-485 peripheral which interface the terminal block). |

**Table 6.2 Legend to *Illustration 6.2***

### 6.2.1 RS-485 Peripheral and Ethernet Units which apply RJ-45

1. Unscrew the blind plugs.
2. Place the M25 cable gland in the cabinet, add the nut and fasten the cable gland.
3. Unscrew the cap of the cable gland and slide it over the cable(s).
4. The special M16 plug provided in the scope of delivery allows one or two cables with pre-assembled RJ-45 plugs to be applied. Adapt the M16 plug as follows:

According to the number of RS-485 or Ethernet cables, cut one or two rubber knob(s) and one or two slot(s) in the side of the sealing insert as indicated with * in the following illustrations. This enables the cable(s) to be inserted from the side.

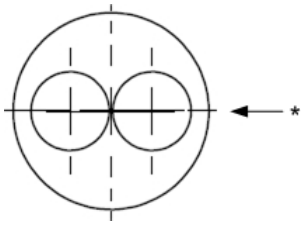


**Illustration 6.3 Cut a Slot**

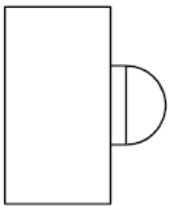

**Illustration 6.4 Sealing Insert Side View**

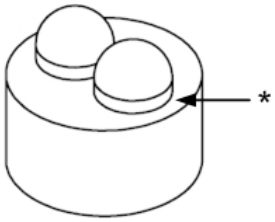


**Illustration 6.5 Cut Rubber Knob**

1. Add the adapted plug to the cable(s) and insert the cable(s) with RJ-45 plug through the cable gland hole.
2. Mount the RJ-45 plug in the RJ-45 socket and fasten the cable gland cap (*Illustration 6.2*).
3. Optionally, the EMC cable clamp (*Illustration 6.2*) can be used for a mechanical fixation of the cable – provided that some of the 6 clamps are free.

### 6.2.2 Other Peripheral Units

Sensors, alarms and RS-485 peripheral units which are applied to the terminal block must use M16 cable glands and EMC cable clamps.

Cable gland:

1. Place the M16 cable gland in the cabinet, add the nut and fasten the cable gland.
2. Unscrew the cap of the cable gland and slide it over the cable.
3. Insert the cable through the cable gland hole.

EMC cable clamps:

1. Loosen the screw in the EMC cable clamp.
2. Strip the cable jacket off in a length equal to the distance from the EMC cable clamp to the terminal block in question, see *Illustration 6.2*.
3. If shielded cable is used strip the cable shield approx. 10 mm and fix the cable in the cable clamp as shown in the following illustrations:
4. 
   - Thin shielded cable (cable shield is folded back over the jacket)
   - Thick shielded cable (> approx. 7 mm)
   - Unshielded cable (alarm output)
5. Fasten the cable clamp screw to secure it and check that the cable shield is mechanically fixed.
6. Fasten the cable gland cap.

Terminal block:

1. Strip off insulation from the wires (approx. 6-7 mm).
2. Insert the wires in the terminal block and fasten the screws to secure them properly.

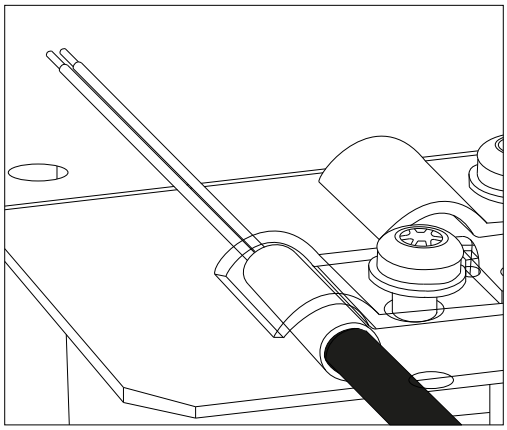


**Illustration 6.6 Thin Shielded Cable (cable shield is folded back over the jacket)**

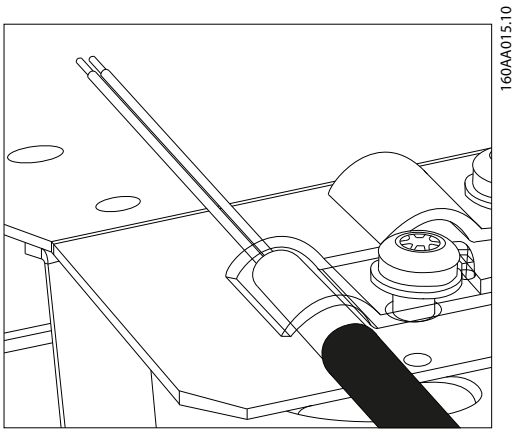


**Illustration 6.7 Thick Shielded Cable (> approx. 7 mm)**

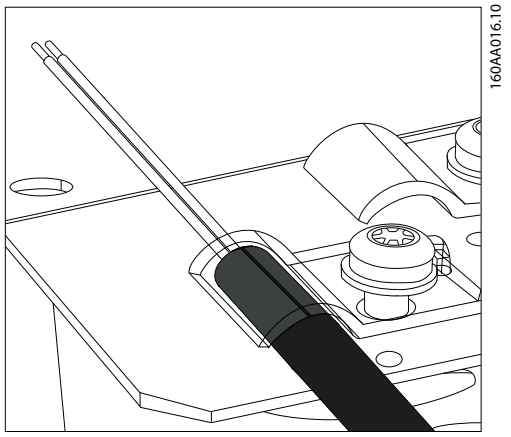


**Illustration 6.8 Unshielded Cable (Alarm Output)**

## 6.3 Sensor Inputs

### 6.3.1 Temperature Sensor

Three temperature inputs are provided.

| Temperature Sensor Input | Function |
|---|---|
| Ambient temperature | Readout via display or web interface and/or communication (logging) |
| PV module temperature | Readout via display or web interface and/or communication (logging) |
| Irradiation sensor temperature | Internal use for temperature correction of irradiation measurement |

**Table 6.3 Temperature Sensor Inputs**

The supported temperature sensor type is PT1000. For layout of the temperature sensor terminal block, see *Illustration 6.1*. For detailed specifications, refer to *11.7 Auxiliary Interface Specifications*. For setup, support, offset, adjustment and more, see*6 Connection of Peripheral Units* for instructions.

### 6.3.2 Irradiation Sensor

The irradiation measurement is read out via the display or web interface and/or communication (logging). The supported irradiation sensor type is passive with a max. output voltage of 150 mV. For layout of the irradiation sensor terminal block, reference is made to the overview of Peripheral Units. For detailed specifications reference is made to *11.6 Mains Circuit Specifications*. For setup, support, sensitivity, adjustment and more, see *6 Connection of Peripheral Units* for instructions.

### 6.3.3 Energy Meter Sensor (S0)

The energy meter input is read out via the display or web interface and communication (logging). The supported energy meter is supported according to EN62053-31 Annex D. S0 is a logical count input.

To change the S0 calibration parameter, first enter the new setting, then restart the inverter to activate the change.

For layout of the S0 terminal block, see *Illustration 6.2*. For detailed specifications reference is made to *11.7 Auxiliary Interface Specifications*. For setup, support, pulses per kWh and more, see *6 Connection of Peripheral Units* for instructions.

## 6.4 Relay Output

The relay output can be used for either of the following purposes:

- as trigger for an alarm or,
- as trigger for self-consumption

The relay is potential free Type NO (Normally Open). For setup, activation and deactivation, refer to *6 Connection of Peripheral Units*.

### 6.4.1 Alarm

The relay can trigger a visual alarm and/or an audible alarm device to indicate events of various inverters (to see which ones, refer to *10.1 Troubleshooting*.

### 6.4.2 Self-consumption

Based on a configurable amount of inverter output power or time of day, the relay can be set to trigger a consumption load (eg. washing machine, heater, etc.). Once triggered, the relay remains closed until the inverter disconnects from grid (eg. at the end of the day).
To avoid overloading the internal relay, it must be ensured that the external load does not exceed the capability of the internal relay (refer to *11.7 Auxiliary Interface Specifications*). For loads exceeding the internal relay capability, an auxiliary contactor must be used.

## 6.5 GSM Modem

For wireless communication, a GSM modem is available.

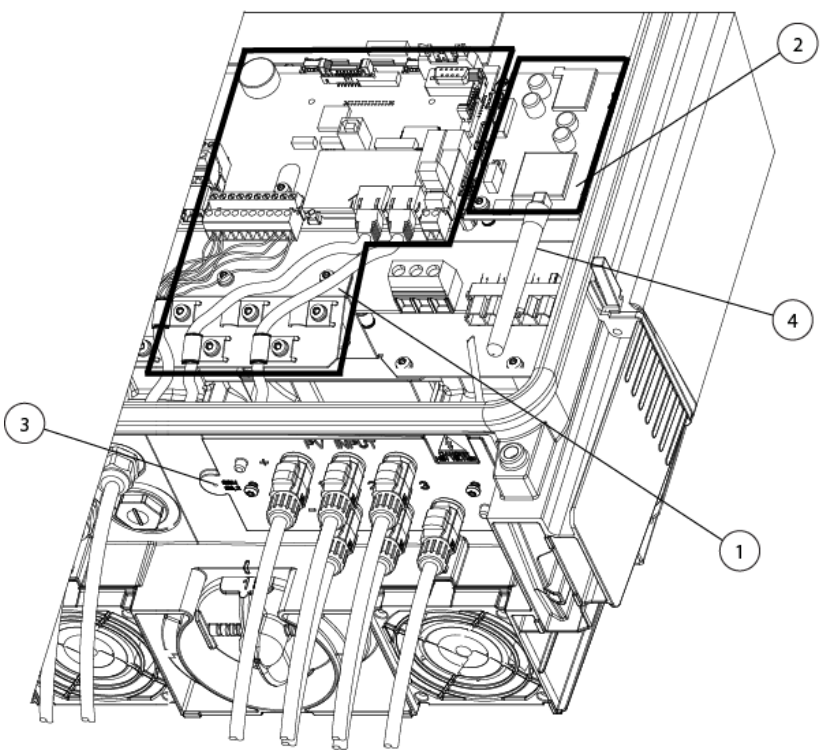


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**Illustration 6.9 Placement of GSM Modem and GSM Antenna**

| | |
|---|---|
| 1 | Communication board |
| 2 | GSM modem |
| 3 | External mounting position for GSM antenna |
| 4 | GSM antenna, internal mounting |

**Table 6.4 Legend to *Illustration 6.9***

For more details, refer to the *GSM Manual*.

## 6.6 Ethernet Communication

The Ethernet communication is used when applying the master inverter functionality via the web interface of the TLX Pro and TLX Pro+ variants.
For layout of the Ethernet Interface, see *11.7 Auxiliary Interface Specifications* and *11.7.1 Network Topology*.

**TLX and TLX+**

For service purposes, Ethernet communication can be used to access the service web interface.

## 6.7 RS-485 Communication

RS-485 communication is used for communication with accessories and for service purposes.

# 7 User Interface

## 7.1 Integrated Display Unit

**NOTE**

**The display activates up to 10 seconds after power up.**

The integrated display on the inverter front gives the user access to information about the PV system and the inverter.

The display has two modes:

1. **Normal:** The display is in use.
2. **Power saving:** After 10 min. of no display activity the back light of the display turns off to save power. Re-activate the display by pressing any key

**Illustration 7.1 Overview of Display Buttons and Functionality**

| | |
|---|---|
| **F1** | View 1/View 2 - Screen |
| **F2** | Status Menu |
| **F3** | Production Log Menu |
| **F4** | Setup Menu |
| **NOTE** **When an F-key is selected the LED above it will light up.** | |
| **Home** | Return to View Screen |
| **OK** | Enter/select |
| **Arrow up** | A step up/increase value |
| **Arrow Down** | A step down/decrease value |
| **Arrow Right** | Moves cursor right |
| **Arrow Left** | Moves cursor left |
| **Back** | Return/de-select |
| **On - Green LED** | On/flashing=On grid/Connecting |
| **Alarm - Red LED** | Flashing=Fail safe |
| | The inverter is configured as master. Icons can be found in the top right corner.* |
| | The inverter is connected to a master. Icons can be found in the top right corner.* |

**Table 7.1 Legend to *Illustration 7.1***

**TLX Pro and TLX Pro+ only.*

**NOTE**

**The contrast level of the display can be altered by pressing the arrow up/down button while holding down the F1 button.**

The menu structure is divided into four main sections

1. **View** - presents a short list of information, read only.
2. **Status** - shows inverter parameter readings, read only.
3. **Production log** - shows logged data.
4. **Setup** - shows configurable parameters, read/ write.

See the following sections for more detailed information.

Three predefined security levels filter user access to menus and options.

Security levels

- Level 0: End-user, no password is needed
- Level 1: Installer/service technician
- Level 2: Installer/service technician (extended)

When logged on as Admin via the web interface, access is at security level 0. Subsequent user accounts created provide access to a predefined subset of menus, according to user profile.
Define user profile at [Plant→Setup→Web Server→Profiles]

Access to levels 1 and 2 requires a service logon, comprising a user ID and a password.

- The service logon provides direct access to a specific security level for the duration of the current day.
- Obtain the service logon from Danfoss.
- Enter the logon via the web interface logon dialog.
- When the service task is complete, log off at [Setup→Security].
- The web interface automatically logs off the user after 10 minutes of inactivity.

Security levels are similar in the inverter display and the web interface.
A security level grants access to all menu items at the same level, and to all menu items of a lower security level. Throughout the manual, a [0], [1] or [2] inserted after the menu item indicates the minimum security level required for access.

## 7.1.1 View

| Parameter | Description |
|---|---|
| [0] Mode: On grid | Displays present inverter mode. See *2.3.3 Definition of Operation Modes*. |
| [0] Prod. today: 12345 kWh | Energy production today in kWh. Value from inverter or S0 energy-meter |
| [0] Power output: 12345 W | Current output power in Watt |
| [0] [ --- utilization bar --- ] | Shows level of inverter utilization as % of max. utilization |

**Table 7.2 Menu Structure - View**

## 7.1.2 View 2

Pressing F1 once more will result in the following screen being shown

| Parameter | Description |
|---|---|
| [0] Grid mgmt | Indicates whether or not any grid management measures are in effect.<br>Only visible if enabled by the current grid code. |
| [0] Performance ratio: 87 %* | Performance ratio is shown if irradiation sensor is available (local or master) |
| [0] Total $CO_2$ saved: 123 T* | Lifetime $CO_2$ emission saved, calculated using configured value |
| [0] Total revenue: 234.5 Euro * | Lifetime revenue, calculated using configured value |

**Table 7.3 Menu Structure - View 2**

* *For TLX Pro only.*

## 7.1.3 Status

| Display Functions | Description |
|---|---|
| [0] Ambient Conditions | Only applicable if sensors are connected |
| [0] Irradiance: 1400 W/m² | Irradiance as detected by sensor. NC if not connected |
| [0] PV module temp: 100 °C | PV module temperature as detected by sensor. NC if not connected |
| [0] Ambient temp: 20°C | Ambient temperature as detected by sensor. NC if not connected |
| [0] Irr. sensor temp: 32 °C | Irradiation sensor temperature as detected by sensor. NC if not connected |
| [0] Photovoltaic | |
| [0] Present values | |
| [0] PV input 1 | |
| [0] Voltage: 1000 V | Voltage detected at PV input 1 |
| [0] Current: 15.0 A | Current detected at PV input 1 |

| Display Functions | Description |
|---|---|
| [0] Power 10000 W | Power detected at PV input 1 |
| [0] PV input 2 | |
| [0] Voltage: 1000 V | |
| [0] Current: 15.0 A | |
| [0] Power 10000 W | |
| [0] PV input 3 | Not visible if inverter only has 2 PV inputs. |
| [0] Voltage: 1000 V | |
| [0] Current: 15.0 A | |
| [0] Power 10000 W | |
| [1] Maximum values | |
| [1] PV input 1 | |
| [1] Voltage: 1000 V | |
| [1] Current: 15.0 A | |
| [1] Power 10000 W | |
| [1] PV input 2 | |
| [1] Voltage: 1000 V | |
| [1] Current: 15.0 A | |
| [1] Power 10000 W | |
| [1] PV input 3 | Not visible if inverter only has 2 PV inputs. |
| [1] Voltage: 1000 V | |
| [1] Current: 15.0 A | |
| [1] Power 10000 W | |
| [0] Insulation Resistance | |
| [0] Resistance: 45 MΩ | PV insulation resistance at start-up |
| [1] Minimum: 45 MΩ | |
| [1] Maximum: 45 MΩ | |
| [0] PV Input Energy | |
| [0] Total: 1234567 kWh | Daily production of all PV input |
| [0] PV1: 123434 kWh | Daily production of PV input 1 |
| [0] PV2: 123346 kWh | Daily production of PV input 2 |
| [0] PV3: 123345 kWh | Daily production of PV input 3. Not visible if inverter only has 2 PV inputs. |
| [0] PV Configuration | |
| [0] PV input 1: | Configuration of PV input 1. The configuration is only shown when the inverter is in Connecting or On grid mode. |
| [0] PV input 2: | |
| [0] PV input 3: | Not visible if inverter only has 2 PV inputs. |
| [0] AC grid | |
| [0] Present Values | |
| [0] Phase 1 | |
| [0] Voltage: 250 V | Voltage on phase 1 |
| [1] 10 min. mean: 248 V | Average voltage sampled over 10 min. on phase 1 |
| [1] L1-L2: 433 V | Phase to phase voltage |
| [0] Current: 11.5 A | Current on phase 1 |
| [1] DC-cont of current: 125 mA | DC content of AC-grid current on phase 1 |
| [0] Frequency: 50 Hz | Frequency on phase 1 |
| [0] Power: 4997 W | Power on phase 1 |
| [1] Apparent P. (S): 4999 VA | Apparent power (S) on phase 1 |
| [1] Reactive P. (Q): 150 VAr | Reactive power (Q) on phase 1 |
| [0] Phase 2 | |
| [0] Voltage: 250 V | |
| [1] 10 min. mean: 248 V | |
| [1] L2-L3: 433 V | |
| [0] Current: 11.5 A | |

| Display Functions | Description |
|---|---|
| [1] DC-cont of current: 125 mA | |
| [0] Frequency: 50 Hz | |
| [0] Power: 4997 W | |
| [1] Apparent P. (S): 4999 VA | |
| [1] Reactive P. (Q): 150 VAr | |
| [0] Phase 3 | |
| [0] Voltage: 250 V | |
| [1] 10 min. mean: 248 V | |
| [1] L3-L1: 433 V | |
| [0] Current: 11.5 A | |
| [1] DC-cont of current: 125 mA | |
| [0] Frequency: 50 Hz | |
| [0] Power: 4997 W | |
| [1] Apparent P. (S): 4999 VA | |
| [1] Reactive P. (Q): 150 VAr | |
| [1] Maximum values of AC | Maximum values registered |
| [1] Phase 1 | |
| [1] Voltage: 250 V | |
| [1] Current: 11.5 A | |
| [1] Power: 4997 W | |
| [1] Phase 2 | |
| [1] Voltage: 250 V | |
| [1] Current: 11.5 A | |
| [1] Power: 4997 W | |
| [1] Phase 3 | |
| [1] Voltage: 250 V | |
| [1] Current: 11.5 A | |
| [1] Power: 4997 W | |
| [0] Residual Current Monitor | |
| [0] Current: 350 mA | |
| [1] Maximum value: 350 mA | |
| [0] Grid management | |
| [0] Apparent power (S) | |
| [0] Max. power (S): 15000 VA | |
| [0] Active power (P) | |
| [0] Lim. type: Off | |
| [0] Max. power (P): 15000 W | |
| [0] PLA: 100% | Only shown if Limit type is “Off” |
| [0] Reactive power (Q) | |
| [0] Setpoint type: Off | Even though the inverter is configured to run PF(P) or Q(U) it will display Constant PF or Constant Q respectively. |
| [0] Value: - | The real-time value of the setpoint for reactive power, the unit depends on the selected setpoint type. |
| [0] Inverter | |
| [0] Country: Germany | |
| [0] Grid: Medium-voltage | |
| [1] DC-bus voltages | |
| [1] Upper: 400 V | |
| [1] Max upper: 500 V | |
| [1] Lower: 400 V | |
| [1] Max lower: 500 V | |
| [0] Internal Conditions | |
| [0] Power module 1: 100 ºC | Temperature detected at the power module |

| Display Functions | Description |
|---|---|
| [1] Power module 2: 100 °C | |
| [1] Power module 3: 100 °C | |
| [1] Power module 4: 100 °C | |
| [0] PCB 1 (Aux): 100 °C | Temperature detected at the PCB |
| [1] PCB 2 (Ctrl): 100 °C | |
| [1] PCB 3 (Pow): 100 °C | |
| [0] Fan 1: 6000 RPM | Speed of the fan |
| [1] Fan 2: 6000 RPM | |
| [1] Fan 3: 6000 RPM | |
| [1] Fan 4: 6000 RPM | |
| [1] Max values | |
| [1] Power module 1: 100 °C | |
| [1] Power module 2: 100 °C | |
| [1] Power module 3: 100 °C | |
| [1] Power module 4: 100 °C | |
| [1] PCB 1 (Aux): 100 °C | |
| [1] PCB 2 (Ctrl): 100 °C | |
| [1] PCB 3 (Pow): 100 °C | |
| [0] Serial no. and SW ver. | |
| [0] Inverter | |
| [0] Prod- and serial number: | |
| [0] 123A4567 | Inverter product number |
| [0] 123456A789 | Inverter serial number |
| [0] Software version: | Inverter software version |
| [0] MAC address: | The MAC address of the communication board |
| [0] ... | |
| [0] Control board | |
| [0] Part-and serial number: | |
| [0] 123A4567 | Control board part number |
| [0] 123456A789 | Control board serial number |
| [0] Software version: | Control board software version |
| [1] Operating time: 1h | |
| [0] Power board | |
| [0] Part-and serial number: | |
| [0] 123A4567 | Power board part number |
| [0] 123456A789 | Power board serial number |
| [1] Operating time: 1h | |
| [0] AUX board | |
| [0] Part-and serial number: | |
| [0] 123A4567 | Aux board part number |
| [0] 123456A789 | Aux board serial number |
| [1] Operating time: 1h | |
| [0] Communication board | |
| [0] Part-and serial number: | |
| [0] 123A4567 | Communication board part number |
| [0] 123456A789 | Communication board serial number |
| [0] Software version: | Communication board software version |
| [1] Operating time: 1h | |
| [0] Func. Safety Processor | |
| [0] Software version: | Functional Safety processor software version |
| [0] Display | |
| [0] Software version: | Display software version |

| Display Functions | Description |
|---|---|
| [0] Upload status | |
| [0] Upload status: Off | Current upload status |
| [0]* Signal strength: | Signal strength. Should preferably be between 16-31. '-' Indicates no signal |
| [0]* GSM status: None | Current GSM network status |
| [0]* Network: | Network to which the modem is connected |
| [0] Failed uploads: 0 | Number of consecutive failed uploads |
| [0] Last error: 0 | Last error ID, see the *GSM Manual* for further assistance |
| [0] - | Time and date of last error |
| [0] Last upload: | |
| [0] - | Time and date of last successful upload |

**Table 7.4 Menu Structure - Status**

* *Visible when communication channel is set to GSM.*

## 7.1.4 Production Log

| Display Functions | Description |
|---|---|
| [0] Total production: | Total production since installation of inverter |
| 123456 kWh | |
| [0] Total operating time: | Total operating time since installation of inverter |
| 137h | |
| [0] Production log | |
| [0] This week | Production from this week |
| [0] Monday: 37 kWh | Production from one day shown in kWh |
| [0] Tuesday: 67 kWh | |
| [0] Wednesday: 47 kWh | |
| [0] Thursday: 21 kWh | |
| [0] Friday: 32 kWh | |
| [0] Saturday: 38 kWh | |
| [0] Sunday: 34 kWh | |
| [0] Past 4 weeks | |
| [0] This week: 250 kWh | Production from this week shown in kWh |
| [0] Last Week: 251 kWh | |
| [0] 2 Weeks ago: 254 kWh | |
| [0] 3 Weeks ago: 458 kWh | |
| [0] 4 Weeks ago: 254 kWh | |
| [0] This year | |
| [0] January: 1000 kWh | Production from one month shown in kWh |
| [0] February: 1252 kWh | |
| [0] March: 1254 kWh | |
| [0] April: 1654 kWh | |
| [0] May: 1584 kWh | |
| [0] June: 1587 kWh | |
| [0] July: 1687 kWh | |
| [0] August: 1685 kWh | |
| [0] September: 1587 kWh | |
| [0] October: 1698 kWh | |
| [0] November: 1247 kWh | |
| [0] December: 1247 kWh | |
| [0] Past years | Yearly production, up to 20 years back |
| [0] This year: 10000 kWh | Production from this year shown in kWh |
| [0] Last year: 10000 kWh | |
| [0] 2 years ago: 10000 kWh | |

| Display Functions | Description |
|---|---|
| [0] 20 years ago: 10000 kWh | |
| ... | |
| [0] Irradiation log | Only visible if it contains non-zero values |
| [0] This week | Irradiation from this week |
| [0] Monday: 37 kWh/m$^2$ | Irradiation from one day shown in kWh/m$^2$ |
| [0] Tuesday: 45 kWh/m$^2$ | |
| [0] Wednesday: 79 kWh/m$^2$ | |
| [0] Thursday: 65 kWh/m$^2$ | |
| [0] Friday: 88 kWh/m$^2$ | |
| [0] Saturday: 76 kWh/m$^2$ | |
| [0] Sunday: 77 kWh/m$^2$ | |
| [0] Past 4 weeks | Irradiation from this week shown in kWh/m$^2$ |
| [0] This week: 250 kWh/m$^2$ | |
| [0] Last week: 320 kWh/m$^2$ | |
| [0] 2 weeks ago: 450 kWh/m$^2$ | |
| [0] 3 weeks ago: 421 kWh/m$^2$ | |
| [0] 4 weeks ago: 483 kWh/m$^2$ | |
| [0] This year | |
| [0] January: 1000 kWh/m$^2$ | Irradiation from one month shown in kWh/m$^2$ |
| [0] February: 1000 kWh/m$^2$ | |
| [0] March: 1000 kWh/m$^2$ | |
| [0] April: 1000 kWh/m$^2$ | |
| [0] May: 1000 kWh/m$^2$ | |
| [0] June: 1000 kWh/m$^2$ | |
| [0] July: 1000 kWh/m$^2$ | |
| [0] August: 1000 kWh/m$^2$ | |
| [0] September: 1000 kWh/m$^2$ | |
| [0] October: 1000 kWh/m$^2$ | |
| [0] November: 1000 kWh/m$^2$ | |
| [0] December: 1000 kWh/m$^2$ | |
| [0] Past years | Yearly irradiation up to 20 years back are shown |
| [0] This year: 10000 kWh/m$^2$ | |
| [0] Last year: 10000 kWh/m$^2$ | |
| [0] 2 years ago: 10000 kWh/m$^2$ | |
| [0] 3 years ago: 10000 kWh/m$^2$ | |
| ... | |
| [0] 20 years ago: 10000 kWh/m$^2$ | |
| [0] Time stamps | |
| [0] Installed: 30-12-99 | Date of first grid connection |
| [0] Power down: 21:00:00 | When the inverter last changed to operation mode off grid |
| [0] Prod. initiated: 06:00:00 | When the inverter last changed to operation mode on grid |
| [0] De-rating | |
| [0] Total de-rate: 0 h | Period of time the inverter has limited power production in total |
| [1] Grid voltage: 0 h | Period of time the inverter has limited power production due to grid voltage |
| [1] Grid current: 0 h | Period of time the inverter has limited power production due to grid current |
| [1] Grid power: 0 h | Period of time the inverter has limited power production due to grid power |
| [1] PV current: 0 h | Period of time the inverter has limited power production due to PV current |
| [1] Temperature: 0 h | Period of time the inverter has limited power production due to excessive temperatures |
| [0] Freq. stabiliza.: 0 h | Period of time the inverter has limited power production due to frequency support. Only visible if enabled by the current grid code. |

| Display Functions | Description |
|---|---|
| [0] Pwr level adjust: 0 h | Period of time the inverter has limited power production due to Power level adjustment. Only visible if enabled by the current grid code. |
| [0] Reactive Power: 0 h | Due to reactive energy support |
| [0] Reactive Power | Only visible if the current grid code is an MV country or custom, and in TLX+ and TLX Pro+ variants. |
| [0] Reactive Energy (underexcited): | |
| 1000 000 VArh | |
| [0] Reactive Energy (overexcited): | |
| 1000 000 VArh | |
| [0] Event log | |
| [0] Latest event: | The latest event is displayed. The number is used for service purposes. |
| 0 | Zero indicates no error. |
| [0] Last 20 events | The latest 20 events are displayed |
| [0] 1 : 29-01-2009 14:33:28 | Date and time of the event |
| [0] Grid 29 off | Group - ID - Status of event |
| [0] 2: 29-01-2009 14:33:27 | |
| [0] Grid 29 on | |
| ... | |
| [0] 20: | |

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**Table 7.5 Menu Structure - Production Log**

## 7.1.5 Setup

| Display Functions | Description |
|---|---|
| [0] Relay | Set relay functionality to either Alarm or Self-consumption |
| [0] Function: Alarm | Default setting of Function |
| [0] Stop Alarm | Stop alarm |
| [0] Test Alarm | Includes testing red LED on front |
| [0] Alarm state: Disabled | |
| [0] Alarm time-out: 60 s | Alarm time limit. If 0, the alarm will be active until fixed |
| [0] Function: Self-consumption | |
| [0] Power level | Minimum level to activate self-consumption |
| [0] Duration | Duration of power level to activate self-consumption |
| [0] Trigger time | Hour of day to activate self-consumption |
| [0] Setup details | |
| [2] Country: Germany | |
| [2] Grid: Medium-voltage | |
| [2] Safety affecting settings | Settings that have influence in functional safety |
| [2] 10 min. mean voltage | |
| [2] Avg. voltage limit: 253 V | Upper 10 min. average voltage limit |
| [2] Time to disconnect: 200 ms | Maximum amount of time before the inverter must disconnect from the grid due to too high avg voltage |
| [2] ROCOF | ROCOF: Rate of Change of Frequency |
| [2] ROCOF limit: 2.50 Hz/s | |
| [2] Time to discon.: 1000 ms | |
| [1] PV Configuration | See *5.6 Parallel PV String Configuration* |
| [1] Mode: Automatic | May be changed to *Manual* if the automatic PV configuration is to be overridden |
| [1] PV input 1: Automatic | |
| [1] PV input 2: Automatic | |
| [1] PV input 3: Automatic | |
| [1] Force inverter power up | Turns on grid supply to CTRL board |

| Display Functions | Description |
|---|---|
| [0] Inverter details | |
| [0] Inverter name: | The inverter's name. Max. 15 characters |
| Danfoss | Max. 15 characters and not only numbers |
| [0] Group name:* | The name of the group the inverter is part of |
| [0] Group 1* | Max. 15 characters. |
| [0] Master mode* | |
| [0] Master mode: Enabled* | |
| [0] Network* | Only visible if Master mode is enabled. |
| [0] Initiate network scan* | |
| [0] Scan progress: 0%* | |
| [0] Inverters found: 0* | |
| [0] Plant name: | The name of the plant. Max. 15 characters. |
| plant name | |
| [1] Reset max. values | |
| [1] Set date and time | |
| [1] Date: dd.mm.yyyy (30.12.2002) | Set the current date |
| [1] Time: hh.mm.ss (13.45.27) | Set the current time |
| [0] Calibration | |
| [0] PV array | |
| [0] PV input 1: 6000 W | |
| [0] PV 1 area: 123 $m^2$ | |
| [0] PV input 2 : 6000 W | |
| [0] PV 2 area: 123 $m^2$ | |
| [0] PV input 3: 6000 W | Not visible if inverter only has 2 PV inputs. |
| [0] PV 3 area: 123 $m^2$ | Not visible if inverter only has 2 PV inputs. |
| [0] Irradiation sensor | |
| [0] Scale (mV/1000 W/$m^2$): 75 | Sensor calibration |
| [0] Temp. coeff: 0.06 %/ºC | Sensor calibration |
| [0] Temp. sensor offset | |
| [0] PV module temp: 2 ºC | Sensor calibration (offset) |
| [0] Ambient Temp: 2º C | Sensor calibration (offset) |
| [0] S0 sensor input | |
| [0] Scale (pulses/kWh): 1000 | Sensor calibration. See note |
| [0] Environment* | |
| [0] $CO_2$ emission factor:* | Value to be used for total $CO_2$ saved calculation |
| [0] 0.5 kg/kWh* | |
| [0] Remuneration per kWh:* | Value to be used for total revenue calculation |
| [0] 44.42 ct/kWh* | |
| [0] Yield start count: 1000 kWh* | A value used as an offset from the current production value when calculating the yield. |
| [0] Communication setup | |
| [0] RS485 setup | |
| [0] Network: 15 | |
| [0] Subnet: 15 | |
| [0] Address: 255 | |
| [0] IP Setup | |
| [0] IP config: Automatic | |
| [0] IP address: | |
| [0] 192.168.1.191 | |
| [0] Subnet mask: | |
| [0] 255.255.255.0 | |
| [0] Default gateway: | |

| Display Functions | Description |
|---|---|
| [0] 192.168.1.1 | |
| [0] DNS server: | |
| [0]123.123.123.123 | |
| [0] GPRS connection setup | |
| [0] SIM PIN code: 0000 | 4-8 characters |
| [0] Access point name: | |
| name | Max. 24 characters |
| [0] User name: | |
| user | Max. 24 characters |
| [0] Password: | |
| password | Max. 24 characters |
| [0] Roaming: Disabled | |
| [0] Data warehouse service | |
| [0] Start log upload | Requires data from at least 10 min. of energy production |
| [0] Upload internal: | Never<br>Hourly<br>Daily<br>Weekly<br>Monthly |
| [0] D.W FTP server address: | |
| www.inverterdata.com | |
| [0] D.W server port: 21 | |
| [0] D.W. server user name: | Default serial number of the inverter |
| user | User name for Data warehouse account, max. 20 chars. |
| [0] D.W server password | |
| password | Password for Data warehouse account, max 20 chars. |
| [0] Communication channel : | |
| [0] Communication channel: GSM | |
| [0] Autotest | Initiate autotest, only applicable with grid code; Italy |
| [0] Status: Off | |
| [0] Ugrid: 234 V | Only visible during voltage tests |
| [0] Utest: 234 V | Only visible during voltage tests |
| [0] Fgrid: 50.03 Hz | Only visible during frequency tests |
| [0] Ftest: 50.03 Hz | Only visible during frequency tests |
| [0] Disconnection time: 53 ms | Not visible in Off and Completed OK states |
| [0] Logging | |
| [0] Interval: 10 min | The interval between each logging |
| [0] Logging capacity: | |
| [0] 10 Days | |
| [1] Delete event log | |
| [1] Delete production log | |
| [1] Delete irradiation log | |
| [1] Delete data log | |
| [0] Web Server* | |
| [0] Reset password* | Resets the password of the Web Server to its default value. |
| [1] Service* | |
| [1] Store settings* | Store inverter settings and data in the display of the inverter. |
| [1] Restore settings* | Restore all inverter settings and data stored in the display of the inverter. |
| [1] Replicate settings* | Replicate all inverter settings to all other known inverters in the network. Only visible if master mode is enabled. |
| [1] Restart comm. board | |
| [1] Restart control board | |
| [1] Grid management | |

| Display Functions | Description |
|---|---|
| [1] Apparent power (S) | |
| [1] Max. power (S): 15000 VA | |
| [1] Active power (P) | |
| [1] Lim. type: Off | When using remotely controlled PLA set this selection to 'Off' |
| [1] Max. power: 15000 W | Only shown when Limit type is 'Absolute limit' |
| [1] Percentage: 100.0% | Only shown when Limit type is '% of AC power' or '% of inst. PV' |
| [1] Reactive power (Q) | |
| [1] Setpoint type: Off | Configure PF(P) and Q(U) using the web interface |
| [1] Off | No setpoint |
| [1] Value: 1.00 | Only shown if Set point type is set to 'Const PF' or 'Const Q' |
| [1] State: Overexcited | |
| [1] Output power limit | |
| [1] Lim. type** | Absolute limit<br>Pct. based on PV (installed PV)<br>Pct. based on ACP (AC power rating)<br>PLA |
| [1] Max. power | |
| [0] Security | |
| [0] Password: 0000 | Password |
| [0] Security level: 0 | Current security level |
| [0] Log out | Log out to security level 0 |
| [0] Service logon | Only to be used by authorised service personnel |
| [0] User name: | |
| [0] user name | |
| [0] Password: | |
| [0] password | |

**Table 7.6 Menu Structure - Setup**

**) For TLX Pro only.*

## 7.2 Overview of Event Log

The event log menu found under Log displays the last event which has occurred.

**Latest event**

Example: The latest event is of type “Grid” and the specific event ID is “29”. This can be used to diagnose the problem. See *12 Appendix A - Event List* for more information on specific events. When an event is cleared, 'Latest event' is set to 0.

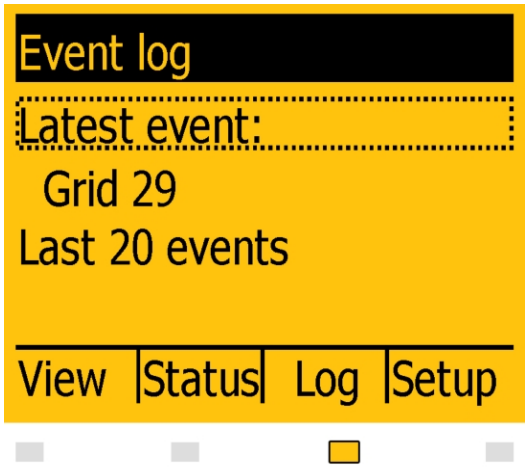


**Illustration 7.2 Latest Event**

**Last 20 events:**

The event log menu contains the submenu Last 20 events, which is a log of the last 20 events. In addition to the information provided by latest event, this log also provides the time and date of the event as well as the status (On/ Off) of the event.

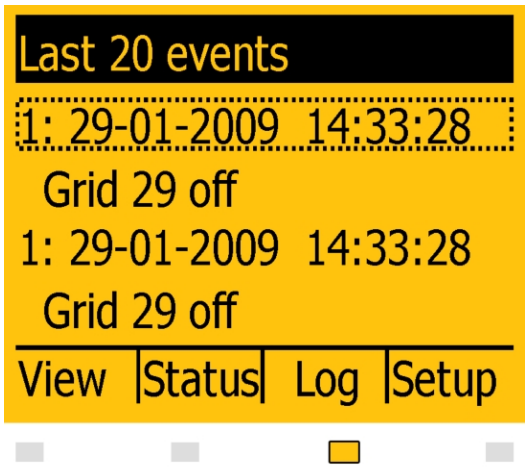


**Illustration 7.3 Past 20 Events**

The latest event is shown at the top of the screen. The event was registered at 14:33:28 on January 29th, 2009. The event is grid related, the specific ID is 29 and the event is no longer active. Note that several entries registered at the same time may be present. This, however, does not mean that the inverter experienced all registered events. Some of the events may be a result of the original event.

## 7.3 Peripheral Units Setup

### 7.3.1 Sensor Setup

This section describes the final step of configuring the sensor inputs using the display or the web interface. Go to the Calibration menu under Setup [Setup → Calibration] and choose the sensor to be configured.

**Temperature Sensor**

The temperature sensor inputs for the PV module temperature and the ambient temperature may be calibrated using an offset ranging from -5.0 to 5.0 °C. Enter the correct values for the sensors under the Temp. sensor offset menu [Setup → Calibration → Temp. sensor offset].

**Irradiation Sensor (Pyranometer)**

In order to use an irradiation sensor, the scale and temperature coefficient of the sensor must be entered. Enter the correct values for the sensor at [Setup → Calibration → Irradiation sensor].

**Energy Meter (S0 sensor)**

In order to use an energy meter (S0 sensor), the scale of the energy meter must be entered in pulses/kWh. This is done under the S0 sensor input menu [Setup→Calibration→S0 sensor input]

The relay provides multiple functions. Set the relay to the function required.

**Alarm**

By default the alarm functionality is disabled.

To activate the alarm,

- go to [Setup→Relay→Function] and select 'Alarm'
- then go to [Setup→Relay→Alarm state] and select 'Enabled'

The alarm functionality (including the relay) can also be tested from this menu. If the alarm is triggered, it will remain active for the period of time defined under Alarm time-out (the value 0 disables the time-out functionality and the alarm will sound continuously). While the alarm is active it may be stopped at any time . To stop the alarm go to [Setup→Relay] and select 'Stop alarm'.

- Stop alarm
- Test alarm
- Alarm state
- Alarm time-out

The alarm is activated by any of the following events

| Event ID | Description |
|---|---|
| 40 | The AC grid has been out of range for more than 10 minutes. |
| 115 | The insulation resistance between ground and PV is too low. This will force the inverter to make a new measurement after 10 minutes. |
| 233-240 | Internal memory error |
| 241, 242 | Internal communication error |
| 243, 244 | Internal error |
| 251 | The functional safety processor has reported Fail safe |
| 350-364 | An internal error has set the inverter in Fail safe |

**Table 7.7 Activation of Alarm**

**Self-consumption**
By default the self-consumption functionality is disabled. To enable self-consumption, go to [Setup→Relay→Function] and select 'Self-consumption'

Once enabled, the self-consumption functionality is activated by output power level or a time of day. Set up the conditions for activation as follows

- Output power level
  - Set 'Power level' to the desired minimum output power level for activation of self-consumption. The default value of 'Power level' is 3000 W.
  - Set the 'Duration' period. Self-consumption will activate when output exceeds the minimum power level, for the period defined in 'Duration'. The default value of 'Duration' is 1 minute. The 'Duration' function serves to avoid inappropriate activation of self-consumption
- Time of day
  - Set 'Trigger time' to the desired time of self-consumption activation, in the format hh:mm:ss. Self-consumption is automatically de-activated when the sun sets and the inverter disconnects from the grid.

### 7.3.2 Communication Channel

Selection of a communication channel is the first step in configuration of email transmission and FTP upload.

To select communication channel:

- Use the display of the master inverter.
- Go to [Setup → Communication setup → Communication channel].
- Select 'GSM' to transmit FTP upload and emails via the optional GSM modem.
- Select 'Local network' to transmit FTP upload and emails via Ethernet.

To fully activate email communication or FTP upload, additional configuration is required in the menus [GPRS connection setup] and [Data Warehouse Service].

Note that when the communication channel is set to 'Not present', no FTP upload or email transmission will take place, even when parameters are configured correctly in [GPRS connection setup] and [Data Warehouse Service].

### 7.3.3 GSM modem

Refer to the *GSM Manual*.

### 7.3.4 RS-485 Communication

The configuration of the RS-485 network interface consists of 3 parameters in the menu [Setup→Communications setup→RS-485 setup] (requires a security level 1 or higher)

- Network
- Subnet
- Address

## NOTE

**The inverter is pre-configured with a unique RS-485 address. If the address is changed manually, ensure that inverters connected in a network do not have identical addresses.**

### 7.3.5 Ethernet Communication

Refer to the section *Auxiliary Interface Specifications* for Ethernet communication configuration details.

## 7.4 Start-up and Check of Settings

### 7.4.1 Initial Setup

The inverter is shipped with a predefined set of settings for different grids. All grid specific limits are stored in the inverter and must be selected at installation. It is always possible to see the applied grid limits in the display. The inverter accounts for daylight saving automatically.

After installation, check all cables and then close the inverter.
Turn on AC at the mains switch.

Follow the setup wizard in the display, or, alternatively, set up the inverter via the web interface.

When prompted by the display select language. This selection has no influence on the operating parameters of the inverter and is not a grid code selection.

Illustration 7.4 Select Language

The language is set to English at initial start-up. To change this setting press the OK button. Press '▼' to scroll down through the languages. Select language by pressing 'OK'.

## NOTE

**To use the default language (English) simply press the 'OK' button twice to select and accept.**

Illustration 7.5 Set Time

Set time as prompted by the display. Press 'OK' to select number. Press '▲' to scroll up through the numbers. Select by pressing 'OK'.
The clock is 24-hour format.

## NOTE

**It is very important to set the time and date accurately as the inverter uses this for logging. If an incorrect time/date is accidentally set, correct it immediately in the set date and time menu [Setup → Inverter details → Set date and time].**

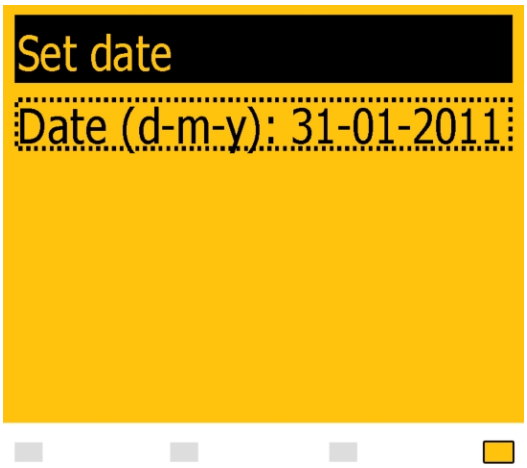


Illustration 7.6 Set Date

Set date as prompted by the display. Press 'OK' to select. Press '▲' to scroll up through the numbers. Select by pressing 'OK'.

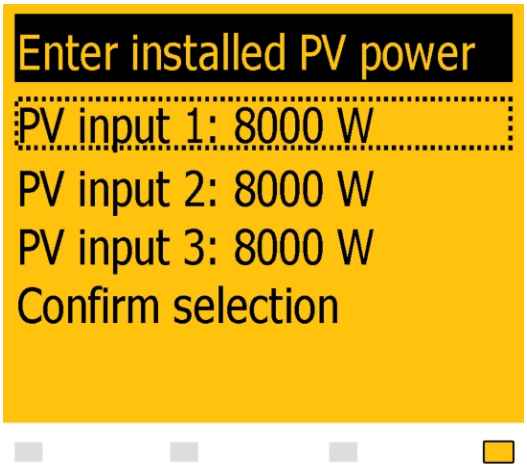


Illustration 7.7 Installed PV Power

Enter the amount of installed PV power for each of the PV inputs. When two or more PV inputs are connected in parallel, each PV input in the parallel group must be set to

the total amount of PV power installed to that group divided by the number of parallel inputs. See *Table 7.8*.

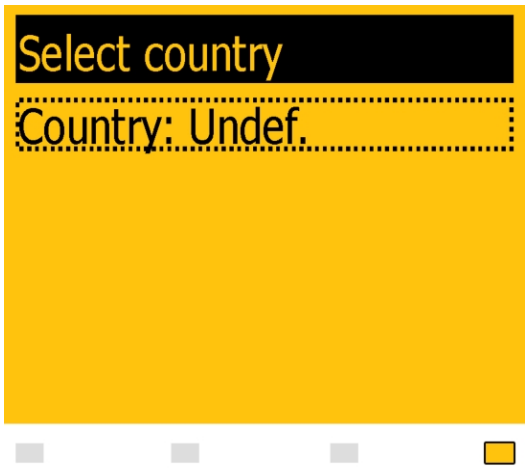


**Illustration 7.8 Select Country**

Select the country in which the inverter is installed. Press '▼' to scroll down the list of countries. To select a country, press 'OK'.

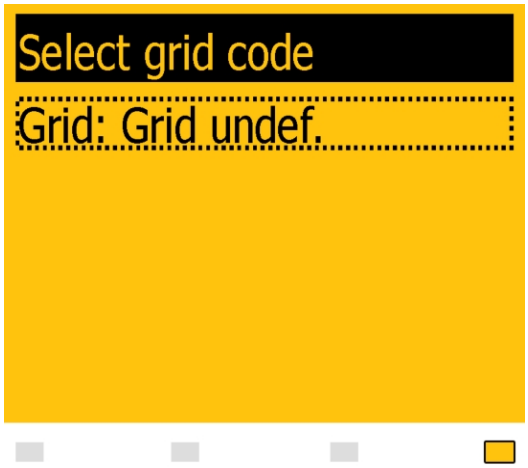


**Illustration 7.9 Select Grid Code**

The display will now show “Select grid”. The grid code is set to “undefined” at initial start-up. To select grid code, press 'OK'. Press '▼' to scroll down through the list of countries. Select the grid code for the installation by pressing ‘OK’. It is very important that the correct grid code is chosen.

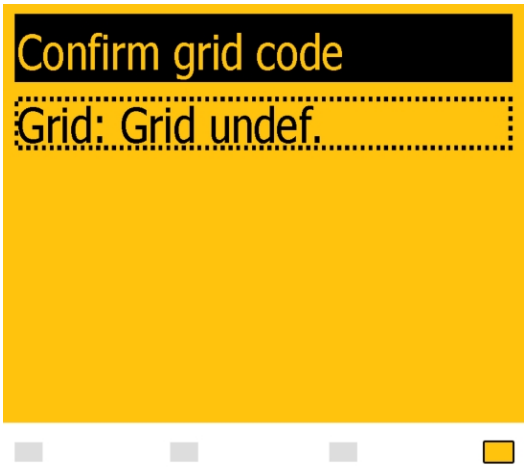


**Illustration 7.10 Confirm Grid Code Selection**

Confirm the choice by selecting the grid code again and press 'OK'. The settings for the chosen grid code have now been activated.

**⚠CAUTION**

**Correct selection of grid code is essential to comply with local and national standards.**

## NOTE

**If the two grid code selections do not match they will be cancelled and it will be necessary to redo the selections. If an incorrect grid code is accidentally accepted at the first selection, simply accept the “Grid: Undefined” in the confirm grid code screen. This will cancel the country selection and a new selection is possible.**

## NOTE

**If an incorrect grid code is selected twice, call service.**

The inverter will start automatically if sufficient solar radiation is available. The start-up will take a few minutes. During this period, the inverter will carry out a self-test.

| Actual Configuration | *"Installed PV power"* to be programmed |
|---|---|
| PV1, PV2 and PV3 are all set into individual mode. The nominal PV power installed are:<br>PV 1: 6000 W<br>PV 2: 6000 W<br>PV 3: 3000 W | <br><br><br>PV 1: 6000 W<br>PV 2: 6000 W<br>PV 3: 3000 W |
| PV1 and PV2 are set into parallel mode and have a total of 10 kW PV power installed. PV3 is set into individual mode and has nominal 4 kW PV power. | PV 1: 5000 W<br>PV 2: 5000 W<br>PV 3: 4000 W |
| PV1 and PV2 are set into parallel mode and have a total of 11 kW PV power installed. PV3 is set to 'Off' and has no PV installed. | PV 1: 5500 W<br>PV 2: 5500 W<br>PV 3: 0 W |

**Table 7.8 Examples of Installed PV Power**

## 7.5 Master Mode

The TLX Pro and TLX Pro+ inverters include a Master mode feature that allows one inverter to be appointed as master inverter. From the web interface of the master inverter, it is possible to access any inverter in the network from one single point using a standard web browser. The master inverter can act as a datalogger, collecting data from all inverters in the network. These data can be displayed graphically from the web interface of the master inverter, or the data can also be uploaded to external webportals or exported directly to a PC. The master inverter is also able to replicate settings and data to the other TLX Pro and TLX Pro+ inverters in the network, enabling easy commissioning and data management of larger networks.

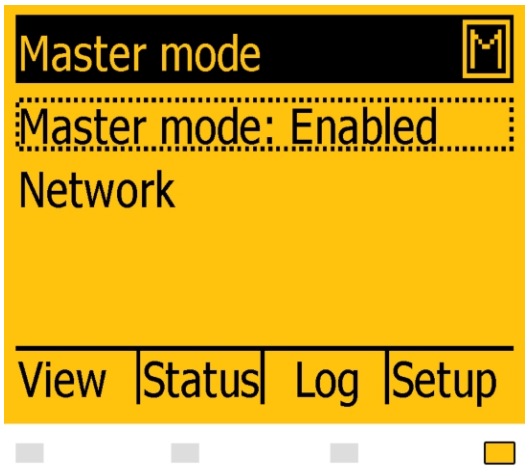


**Illustration 7.11 Master Mode**

To enable Master mode go to the *Inverter details* menu [Setup→Inverter details→Master mode] and set Master mode to *Enabled.* Ensure that no other master inverters are present in the network prior to carrying out this action. When Master mode is enabled, it is possible to initiate a network scan [Setup→Inverter details→Master mode→Network]. This will show all inverters connected to the master inverter.

## NOTE

**Only 1 master per network is possible.**

## NOTE

**The master inverter can operate in a network of up to 99 follower inverters.**

# 8 Web Server Quick Guide

## CAUTION

**All inverters connected to the internet through Ethernet must be behind a firewall.**

## 8.1 Introduction

These instructions describe the TLX Pro web interface, which facilitates remote access to the inverter.
The Web Server is available in TLX Pro and TLX Pro+ inverters only.
Refer to the download area at *www.danfoss.com/solar* for the newest instructions.

## 8.2 Supported Characters

For all language versions, the web interface software supports characters compatible with Unicode.

For plant, group and inverter name, only the following characters are supported:

| | |
|---|---|
| Letters | abcdefghijklmnopqrstuvwxyz |
| Capital letters | ABCDEFGHIJKLMNOPQRSTUVWXYZ |
| Numbers | 0123456789 |
| Special characters | - _. |

**Table 8.1 Supported Characters**

## NOTE

**No spaces are allowed in inverter name.**

## 8.3 Access and Initial Setup

### 8.3.1 Access via PC Ethernet Interface

**Setup Sequence:**

1. Select which inverter will be set up as master (usually the one connected to the PC or closest to the router (in a daisy chain) + sensors connected).
2. Open the cover of this inverter. Refer to the *TLX Series Installation Manual* for instructions.
3. Connect the inverter RJ-45 interface to the PC Ethernet interface using a patch cable (network cable cat5e, crossed or straight through).
4. On the PC, wait until Windows*) reports limited connectivity (if no DHCP is present). Open the internet browser and ensure pop-ups are enabled.
5. Type http://invertername in the address field:
   - Find the serial number on the product label, located on the side of the housing.
   - 'Invertername' is the final 10 digits of the serial number (1).

**) Only works for Windows 95 and XP. For MAC and Windows 7 (and newer), the setup wizard in the display must be used for initial start-up of the inverter.*

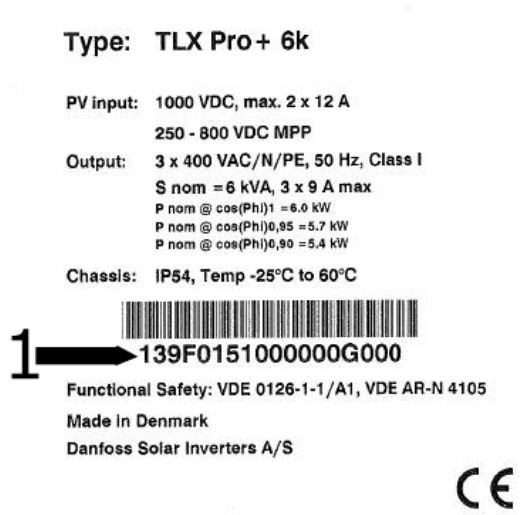
Type: TLX Pro+ 6k
PV input: 1000 VDC, max. 2 x 12 A
250 - 800 VDC MPP
Output: 3 x 400 VAC/N/PE, 50 Hz, Class I
S nom = 6 kVA, 3 x 9 A max
P nom @ cos(Phi)1 = 6.0 kW
P nom @ cos(Phi)0,95 = 5.7 kW
P nom @ cos(Phi)0,90 = 5.4 kW
Chassis: IP54, Temp -25°C to 60°C
1
139F0151000000G000
Functional Safety: VDE 0126-1-1/A1, VDE AR-N 4105
Made in Denmark
Danfoss Solar Inverters A/S
CE

**Illustration 8.1 Product Label**

6. At initial start-up, the inverter runs a setup wizard.

## 8.4 Operation

### 8.4.1 Web Interface Structure

The web interface overview is structured as follows.

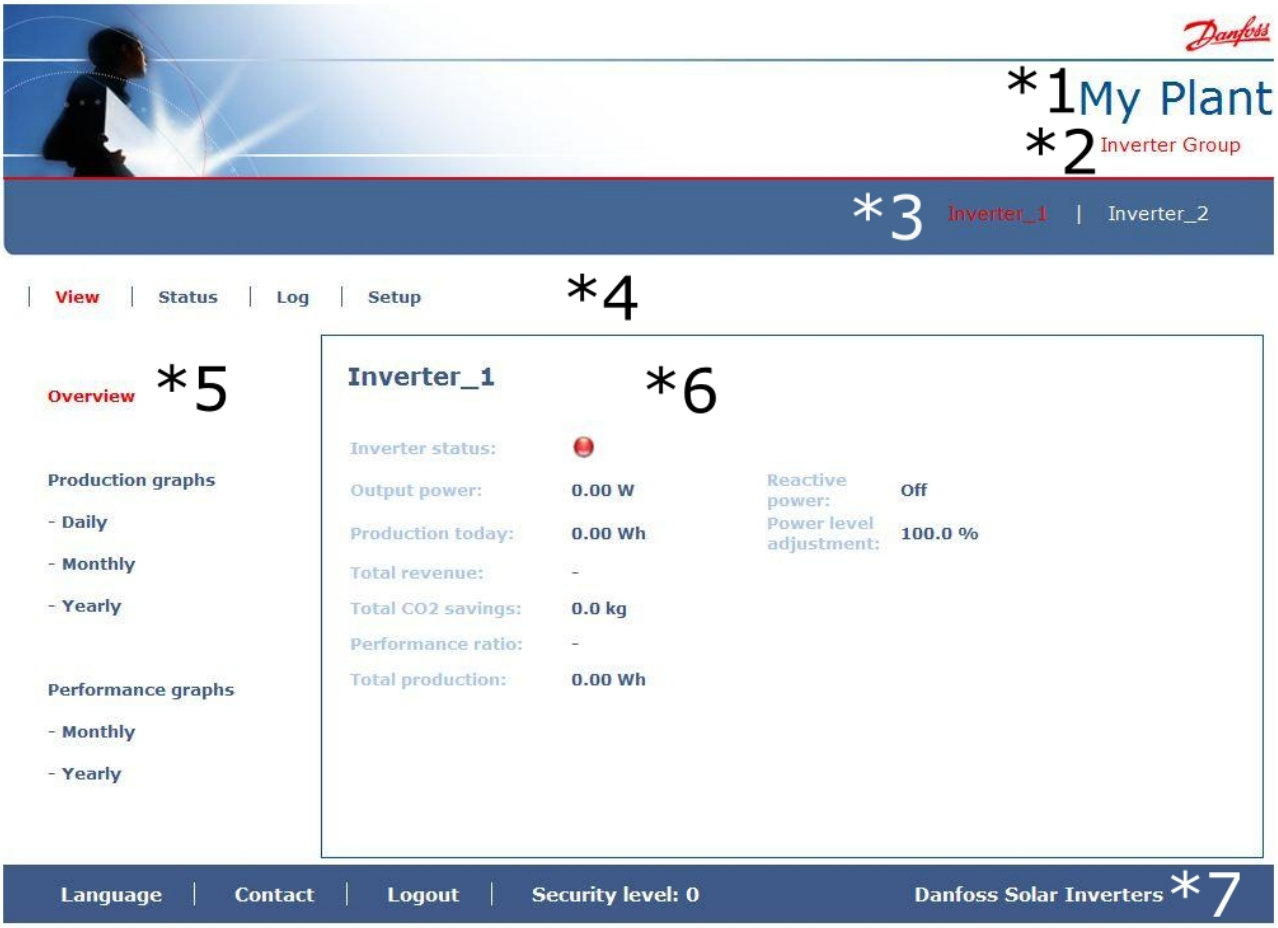


Illustration 8.2 Overview

8

1. **Plant name:** Displays the current plant name:
    - Click on the plant name to display the plant view.
    - Change the plant name at [Setup→Plant details].
2. **Group menu:** Displays groups of inverters:
    - Inverters join group 1 by default
    - Click on a group name to display the group view, and a list of inverters in the group.
    - Change the group name via [Setup→Inverter details] in the inverter view.
3. **Group members:** Displays the inverter names in the group currently selected. The default inverter name is based on the serial number (see *8.3 Access and Initial Setup*):
    - Click on an inverter name to display the inverter view.
    - Change the name of the inverter via [Setup→Inverter details] in the inverter view.
4. **Main menu:** This menu corresponds to the inverter display main menu.
5. **Sub menu:** The sub menu corresponds to the main menu item currently selected. All sub menu items belonging to a particular main menu item are displayed here.
6. **Content area:** The web interface main menu and sub menus are identical to the menus in the inverter display. The sub menu content displayed here corresponds to the sub menu selected: [Overview]. On some pages, a horizontal menu is provided for improved readability.
7. **Footer:** Options on the footer bar:
    - **Language:** Opens a pop-up window. Click on the country flag to change the language of the web interface to the desired language for the active session.
    - **Contact:** Opens a pop-up window which displays Danfoss contact information.
    - **Logout:** Opens the log in / log out dialog box.
    - **Security level:** Displays the current security level as explained in *7.1.1 Security Levels*.

## NOTE

**The content of the main menu changes depending on which view is currently selected: the plant, a group of inverters or an individual inverter. The active view is indicated by text in red.**

## 8.4.2 Plant, Group and Inverter Views

The overview screens for plant view, group view, and inverter view display the same overall status information.

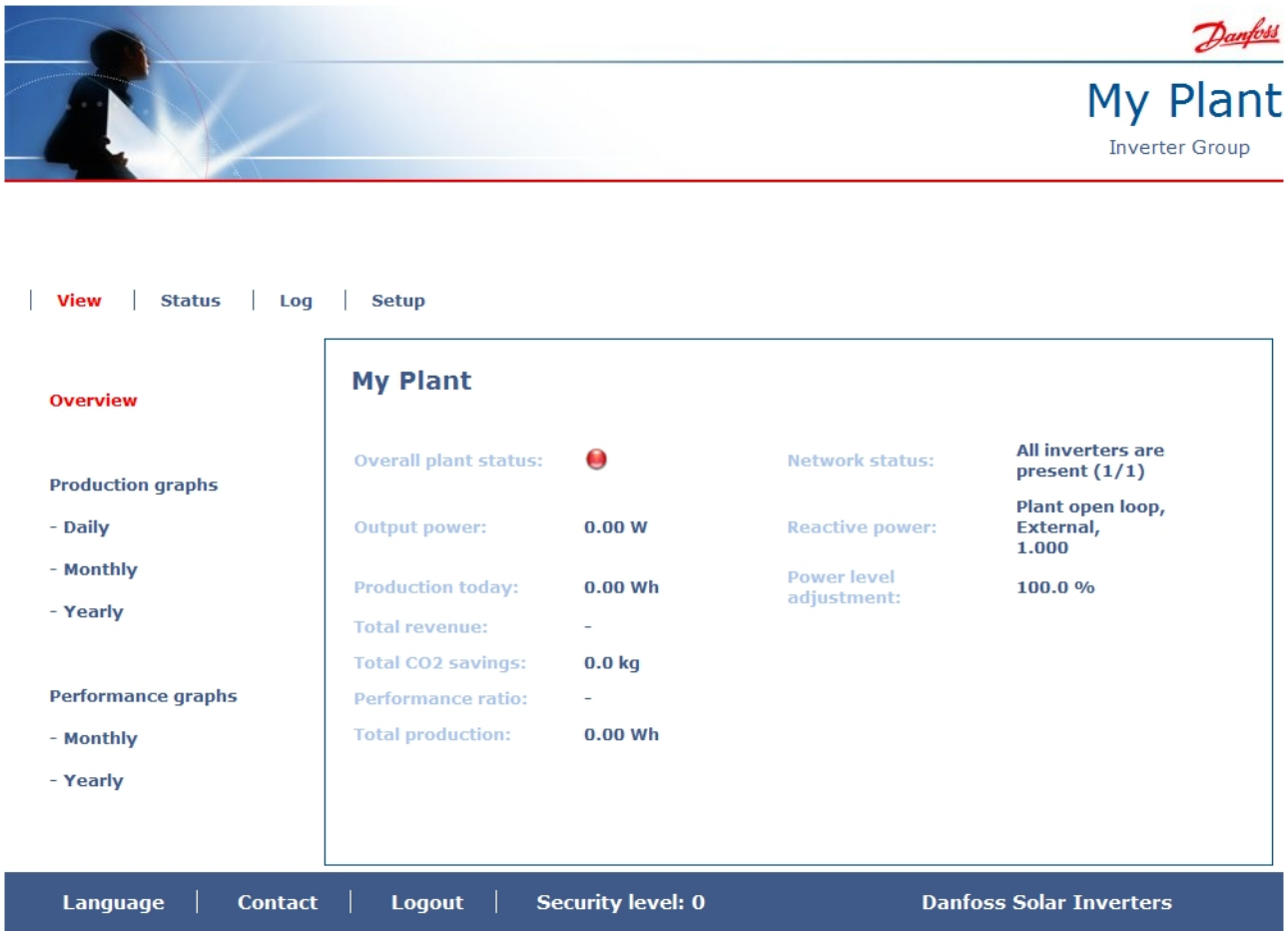


Illustration 8.3 Plant View

8

| Item | Unit | View | | Description |
|---|---|---|---|---|
| | | Plant and Group | Inverter | |
| Overall plant status | - | x | | **Red:** Plant PR <50%, or:<br>Any inverter in the network<br>- in *fail safe* mode, or<br>- missing from the scan list, no contact with the master<br>**Yellow:** Any inverter in the network<br>- with PR <70%, or<br>- in *Connecting* or *Off grid* mode<br>**Green:** Plant PR ≥70%, and<br>- all inverters with PR ≥70%, and<br>- all inverters in *On grid* mode |
| | | | x | **Red:** Inverter PR <50%, or inverter has an error<br>**Yellow:** Inverter PR between 51% and 70%, or inverter in *Connecting* mode<br>**Green:** No errors, and<br>- inverter PR ≥70%, and<br>- inverter in *On grid* mode |
| Current production | kW | x | x | Real time energy production level |
| Yield today | kWh | x | x | Cumulative yield for the day |
| Total revenue | Euro | x | x | Cumulative revenue earned since initial startup |
| Total $CO_2$ saving | kg | x | x | Cumulative $CO_2$ saved since initial startup |
| Performance ratio | % | x | x | Real time performance ratio |
| Total yield | kWh | x | x | Cumulative yield since initial startup |
| Power limit adjustment | % | | x | Power limit as % of nominal inverter AC output rating |

**Table 8.2 Plant Overview**



## NOTE

**To calculate performance ratio (PR), an irradiation sensor is required, go to [Setup → Calibration].**

## 8.5 Additional Information

Refer to the *TLX Series Web Server User Manual* to learn more about:

- Inverter start-up and check of settings
- Messaging
- Graphs
- Remote access
- Web portal upload
- Logging capacity and changing the logging interval
- Settings backup and restore

# 9 Ancillary Services

## 9.1 Introduction

Ancillary services comprise inverter functionalities which aid transport of power on grids and contribute to grid stability. The ancillary services required for a particular PV system are determined by the point of common coupling (PCC) and the grid type to which the system is connected. The PCC is the point where the PV system is connected to the public electricity grid.

In residential installations, the domestic circuits and the solar inverters are usually connected to the grid at one common point. The installation becomes part of the low-voltage (LV) distribution system. Commercial installations are normally larger and therefore connected to the medium-voltage (MV) system. Large-scale commercial systems, such as power plants, can be connected to the high-voltage (HV) grid.

Each of the power systems has individual ancillary service requirements. Depending on the location and the DNO, some of these services will be mandatory and others are optional. Mandatory requirements are automatically configured through the selected grid code. Optional services are configured by the installer during commissioning.

Grid support can be divided into the following main groups, which will be covered in subsequent sections:

- Dynamic Network Support
- Active Power Control
- Reactive Power Control

### 9.1.1 Active/Reactive Power Theory

The principle in generating reactive power is that the phases between the voltage and the current are shifted in a controlled way.
Reactive power cannot transport consumable energy, but it generates losses in power lines and transformers and is normally unwanted.
Reactive loads can be either capacitive or inductive in nature, depending on the current leads or lags in relation to the voltage.
Utility companies have an interest in controlling reactive power in their grids, for example in:

- Compensation for inductive loading by injection of capacitive reactive power
- Voltage control

To compensate for this a generator exchanging reactive power operates either at a lagging power factor, also known as over-excited, or at a leading power factor, also known as under-excited.

The technical definition of reactive power:

- Active power (P) measured in Watts [W]
- Reactive power (Q) measured in volt-ampere reactive [VAr]
- Apparent power (S) is the vector-sum of P and Q and is measured in volt-ampere [VA]
- φ is the angle between current and voltage and thus between P and S

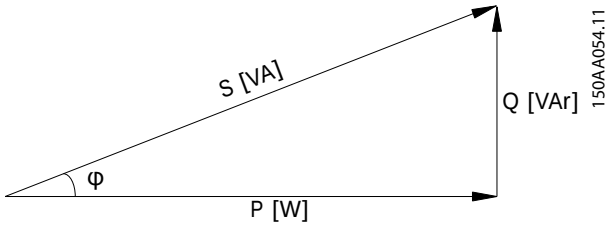


**Illustration 9.1 Reactive Power**

In the inverter, the reactive power is defined either as:

- **Q**: The amount of reactive power as a percentage of the nominal apparent power of the inverter.
- **PF, Power Factor*)**: The ratio between P and S (P/S), also referred to as: Cos(φ).

*) Displacement Power Factor at fundamental frequency.

## 9.2 Ancillary Services Overview

The following table outlines the individual ancillary services.

| | TLX | TLX+ | TLX Pro | TLX Pro+ |
|---|---|---|---|---|
| **Danfoss[5] Grid management** | | | | |
| Remotely controlled active power /PLA | CLX Home GM[2]<br>CLX Standard GM[3] | | CLX GM[4]<br>CLX Home GM[2]<br>CLX Standard GM[3] | |
| Remotely controlled reactive power | - | CLX Home GM[2]<br>CLX Standard GM[3] | CLX GM[4]<br>CLX Home GM[2]<br>CLX Standard GM[3] | |
| Dynamic reactive power (PF(P) | - | ✓ | - | ✓ |
| Dynamic reactive power Q(U) | - | | | ✓ |
| Constant reactive power PF and Q | - | CLX Home GM[2]<br>CLX Standard GM[3] | - | ✓[4] |
| Fixed active power (P) limit | ✓ | | | |
| Fixed apparent power (S) limit | ✓ | | | |
| Closed loop reactive power control | - | ✓[6] | - | ✓[6] |
| Open loop reactive power control | - | CLX Home[2]<br>CLX Standard GM[3] | - | ✓[4] |

**Table 9.1 Grid Management**

*1) Max. 50 inverters per network.*

*2) Max. 3 inverters per network.*

*3) Max. 20 inverters per network.*

*4) Ethernet, max. 100 inverters per network.*

*5) Or by other third-party products, via RS-485.*

*6) By third-party product.*

## NOTE

**Check local legal requirements before changing settings for ancillary services.**

## 9.3 Dynamic Network Support

The grid voltage usually has a smooth waveform, but occasionally the voltage drops or disappears for several milliseconds. This is often due to short-circuit of overhead lines, or caused by operation of switchgear or similar in the high-voltage transmission lines. In such cases the inverter can continue to supply power to the grid using fault ride through (FRT) functionality.
Continuous power supply to the grid is essential:

- to help prevent a complete voltage black-out and stabilise the voltage in the grid.
- to increase the energy delivered to the AC grid.

**Zero Current Setting**
For special requirements from the DNO, a zero current 'LVRT' option is available. It provides no current in fault ride through situations.

The inverter has a high immunity against voltage disturbances as depicted in *9.3.1 Example - Germany MV*.

### 9.3.1 Example - Germany MV

**How FRT works**
***Illustration 9.2*** **shows the requirements to be followed by FRT. This example is for German medium-voltage grids.**

- **Above line 1**
  For voltages above line 1, the inverter must not disconnect from the grid during FRT, under any circumstances.
- **Area A**
  The inverter must not disconnect from grid, for voltages below line 1 and left of line 2. In some cases the DNO permits a short-duration disconnection, in which case the inverter must be back on grid within 2 seconds.
- **Area B**

To the right of line 2, a short-duration disconnection from grid is always permitted. The reconnect time and power gradient can be negotiated with the DNO.

- **Below line 3**
  Below line 3, there is no requirement to remain connected to grid.

When a short-duration disconnection from grid occurs,

- the inverter must be back on grid after 2 seconds;
- the active power must be ramped back at a minimum rate of 10% of nominal power per second.

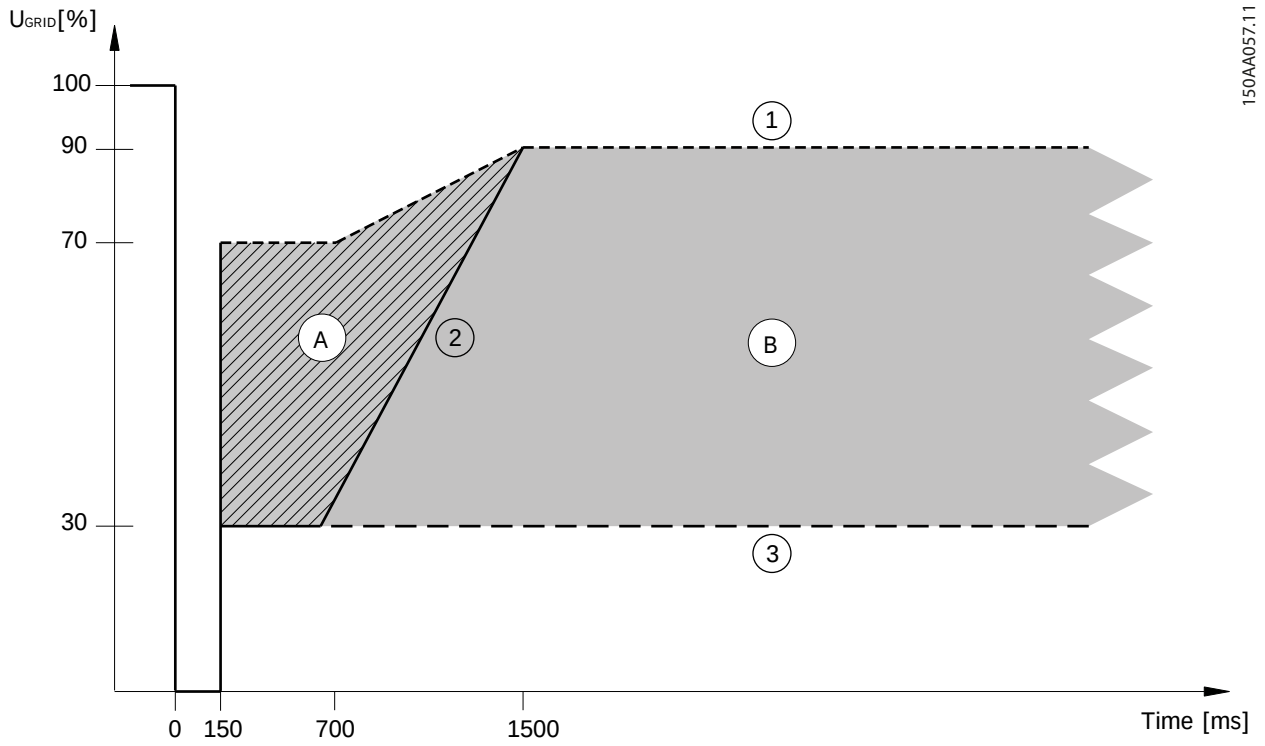


Illustration 9.2 German Example



## NOTE

**To enable reactive current during FRT, select a medium-voltage grid code.**

**Parameters related to FRT**

These parameters are set automatically upon selecting the grid code.

| Parameter | Description |
|---|---|
| FRT upper threshold level | Upper grid voltage magnitude for engaging a high-voltage FRT |
| FRT lower threshold level | Lower grid voltage magnitude for engaging a low-voltage FRT |
| Static reactive power, k | Ratio between additional reactive current to be injected during the FRT and the depth of the sag, $k= (\Delta I_B/I_N) / (\Delta U/U) \geq 2.0$ p.u. |
| Transition time | Duration of period after the sag has cleared, where reactive current is still injected. |

Table 9.2 Parameters related to FRT

In addition to remaining on grid during the fault, the inverter can deliver reactive current to support the grid voltage.

## 9.4 Active Power Control

The inverter range supports active power control, which is used to control the active output power of the inverter. The control methods of the active output power are described below.

### 9.4.1 Fixed Limit

To ensure that the PV system is not producing more power than allowed the output power can be limited to a fixed upper amount set as:

- Absolute value [W]
- Percentage based on total installed PV power [%]
- Percentage based on nominal AC output power [%]

**Configuration:**
To configure fixed limits, security level 1 is required.

- For all TLX inverters, via the display, navigate to: [Setup → Grid management → Output power limit]
- For TLX Pro / TLX Pro+, via the web interface, navigate to:
  [Inverter level: Setup → Grid Management]
- For TLX / TLX+, via the service interface, navigate to:
  [Inverter level: Setup → Grid Management]

### 9.4.2 Dynamic Value

The output power is reduced as a variable of the grid frequency. There are two methods for reducing the output power: ramp and hysteresis.

**Primary frequency control – ramp method**
The inverter reduces output power if the grid frequency exceeds F1. Reduction occurs at a preconfigured rate, which is the ramp (R) shown in the illustration.
When the frequency reaches F2, the inverter disconnects from grid. When the frequency decreases below F2, the inverter reconnects to grid and ramps up power at the same rate as for the reduction.

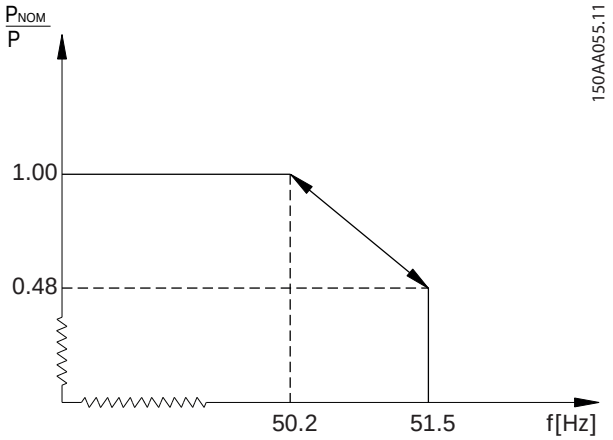


**Illustration 9.3 Primary Frequency Control – Ramp Method**

**Primary Frequency control – hysteresis method**
To support grid stabilisation, the inverter reduces output power if the grid frequency exceeds F1. Reduction occurs at a preconfigured rate, which is the ramp (R) shown in the illustration. The reduced output power limit is maintained until the grid frequency has decreased to F2. When the grid frequency has decreased to F2, the inverter output power increases again following a time ramp T. When the frequency decreases below F2, the inverter reconnects to grid and ramps up power at the same rate as for the reduction. If the grid frequency continues to increase, the inverter disconnects at F3.

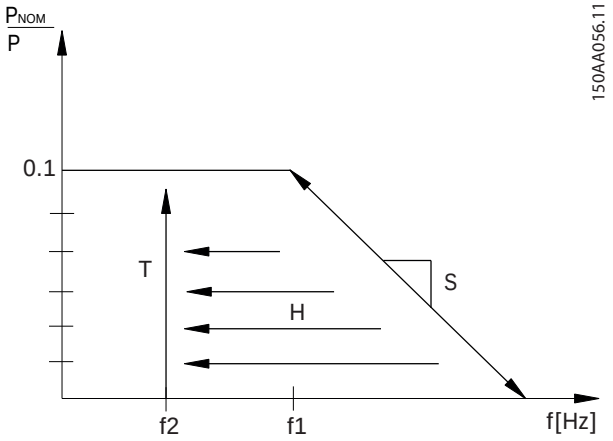


**Illustration 9.4 Primary Frequency Control – Hysteresis Method**

### 9.4.3 Remotely Controlled Adjustment of Output Power Level

The inverter supports remotely controlled adjustment of the output power level. This is the Power Level Adjustment function (PLA). The inverter can handle the control of output power, or it can be handled by CLX monitoring and grid management products or third-party external device.

**TLX Pro/TLX Pro+:**
When using the master functionality of TLX Pro and TLX Pro+ to manage the control of the output power level, the Danfoss CLX GM is required as interface device between the DNO signal interface (radio receiver) and the inverter.

The master inverter uses the DNO signal information to determine the requested output power level (PLA) commanded by the DNO and communicates this to the followers in the network.

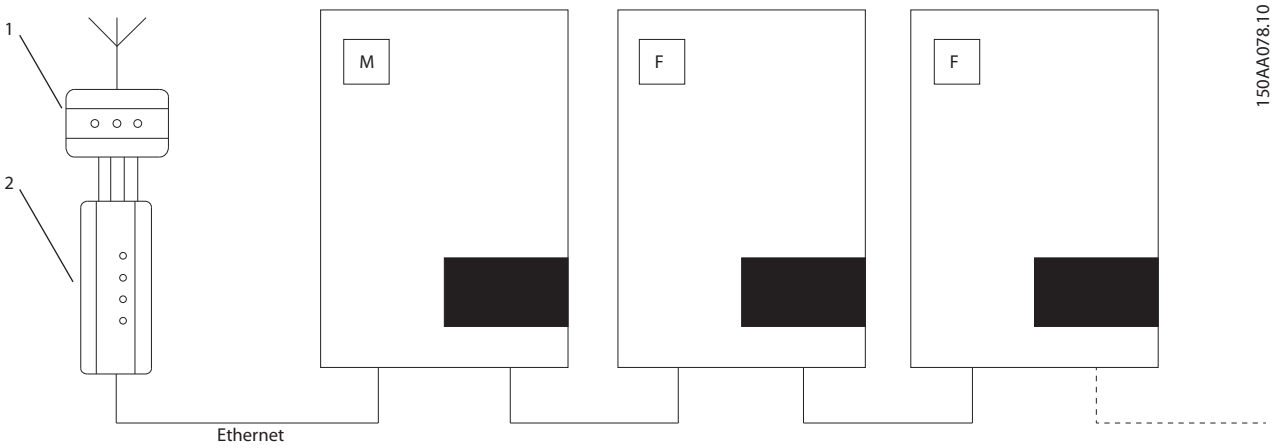


**Illustration 9.5 Example: Managing Power Using TLX Pro and TLX Pro+**

| | |
|---|---|
| 1 | DNO interface (radio receiver) |
| 2 | Danfoss CLX GM |

**Table 9.3 Legend to *Illustration 9.5***

9

**TLX/TLX+ with CLX monitoring and grid management products or third-party external device**
Based on the input from a DNO signal interface, an CLX monitoring and grid management products or third-party external device send PLA commands directly to the inverter via the RS-485 interface. Each inverter then uses this information to determine its output power limit. Both Danfoss and third-party products are available for external control (for more information about relevant products, see the supplier manuals).

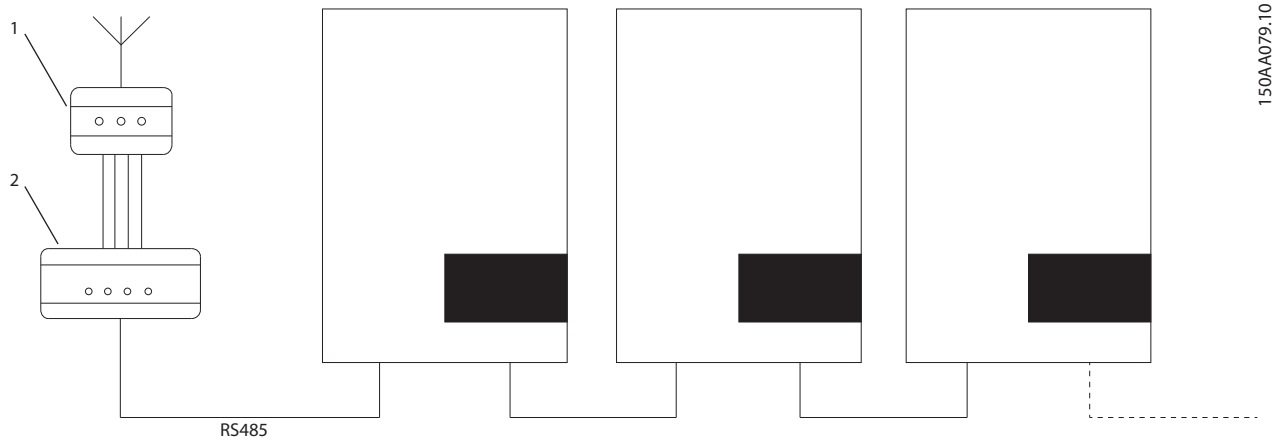


**Illustration 9.6 Example: Managing Power Using CLX Monitoring and Grid Management Products or Third-party External Device**

| | |
|---|---|
| 1 | DNO interface (radio receiver) |
| 2 | CLX monitoring and grid management product or third-party device |

**Table 9.4 Legend to *Illustration 9.6***

**Configuration**
To configure remotely controlled output power, access at security level 1 is required.

Remotely controlled output power is configured in the CLX monitoring and grid management product or third-party device. See manual for CLX product or third-party party device.

- For TLX Pro/TLX Pro+, via the web interface, navigate to:
  [Inverter level: Setup→Grid Management]

## 9.5 Reactive Power Control

The TLX+ and TLX Pro+ inverters support reactive power control, which is used to control the reactive output power of the inverter. The control methods of the reactive output power are described below.

During *Stand-by* and *Off grid*, the control functions for reactive power cannot be in operation, which results in exchange of reactive power:

- in *Stand-by* mode from LCL and EMC filter components
- in *Off grid* mode from EMC filter components

Main contributor for exchange of reactive power is the LCL filter.

### 9.5.1 Constant Value

The inverter can be set to provide a fixed reactive power value in one of the following ways:

- Off
- Constant reactive power Q
- Constant power factor PF

**Off**
The inverter will not use any internal setpoint for reactive power, but an external setpoint source can be used. TLX+ inverters support a number of third-party grid management units for managing reactive power. Set the 'setpoint type' to “Off”. This will enable the inverter to accept a setpoint for PF and Q, transmitted via RS-485 from the external source.

**Constant Reactive Power Q**
The inverter will generate a fixed level of reactive power, specified as a percentage of the inverter’s nominal apparent power (S). The value of constant reactive power Q can be set in the range from 60% (under-excited) to 60% (over-excited). The value can be maintained from 3% of nominal power.

**Constant Power Factor PF**
Constant power factor specifies a fixed relation between active and apparent power (P/S), i.e. a fixed Cos (φ). The power factor PF can be set in the range from: 0.8 under-excited to 0.8 over-excited. The reactive power generated by the inverter is thus dependent on the active power generated.

Example:

- PF=0.9
- Generated active power (P)=10.0 kW
- Apparent power (S)=10.0/0.9=11.1 kVA

Reactive power (Q)=√(11.1-10.0)=4.8 kVAr

**Configuration**
To configure constant reactive power, access at security level 1 is required.

To configure the setpoint of Q or PF, navigate to:

- Via the web interface:
  [Plant level: Setup→Grid Management]
- Via the service web interface:
  [Inverter level: Setup→Grid Management]
- Via the display:
  [Inverter level: Setup→Grid Management]

### 9.5.2 Dynamic Value

The dynamic reactive control requires either a TLX+ inverter with CLX monitoring and grid management product or third-party device, or a TLX Pro+ inverter.

**Setpoint curve PF(P)**
The PF(P) curve is either pre-configured in each inverter (via the selected grid code) or configured manually in the web interface. The PF(P) control is thus operating on inverter level, measuring the output power of the unit and delivering reactive power accordingly.

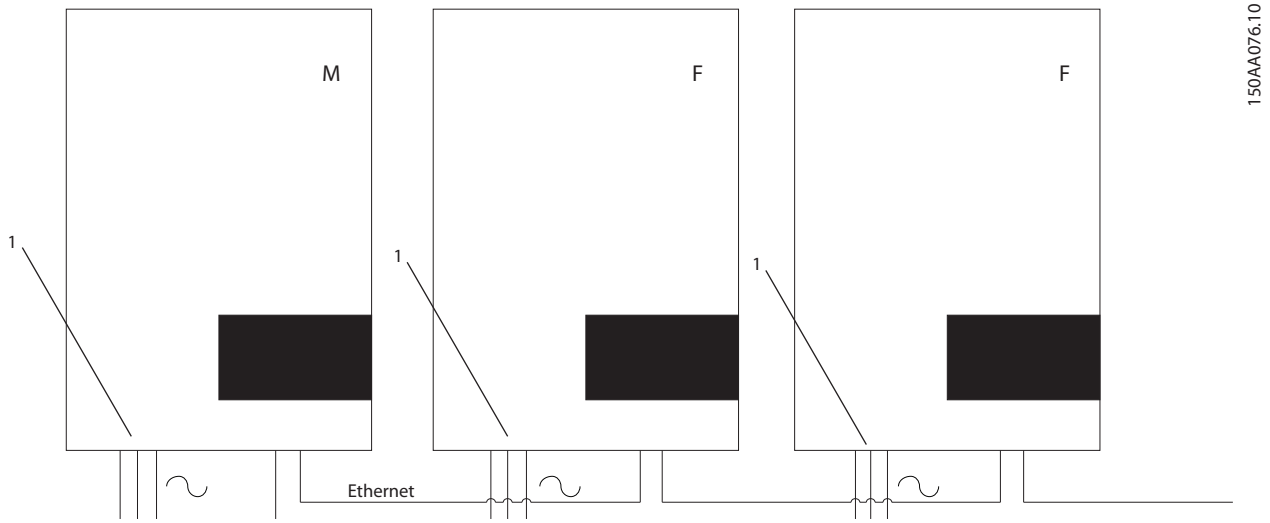


Illustration 9.7 Setpoint curve PF(P)

| | |
|---|---|
| 1 | Active output power measurement |

Table 9.5

### Setpoint curve Q(U)

The inverter controls reactive power as a function of the grid voltage U. The values for the setpoint curve are determined by the local utility company and must be obtained from them. The Q(U) curve is configured on plant level. The master measures grid voltage and determines and delivers reactive P(Q) accordingly. The Q value is sent to all followers in the network.

9

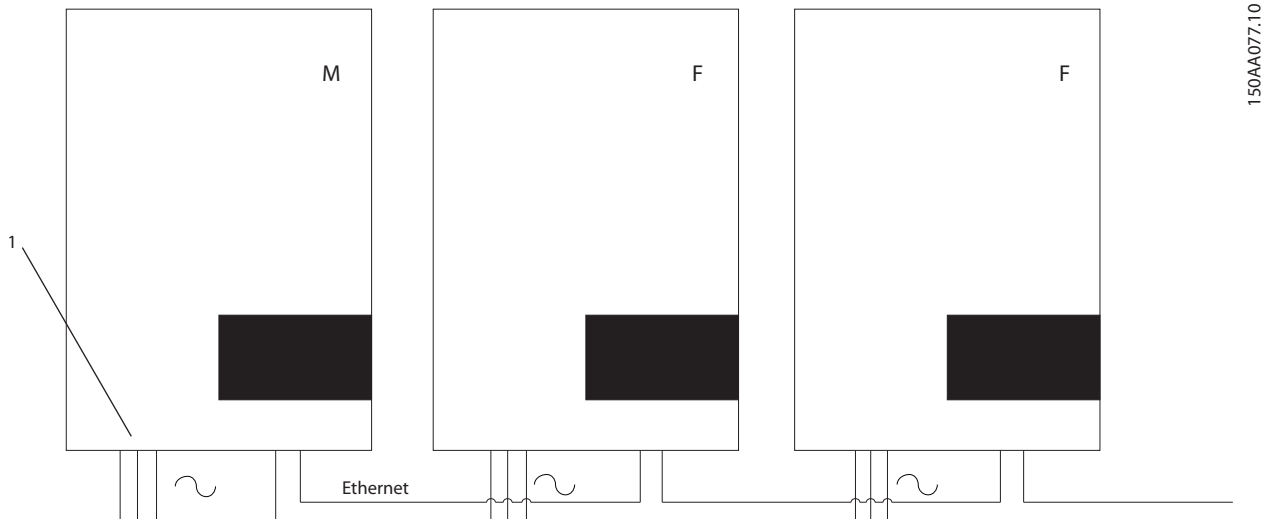


Illustration 9.8 Setpoint Curve Q(U)

| | |
|---|---|
| 1 | Grid-voltage measurement |

Table 9.6

### Configuration

To configure variable reactive power, security level 1 is required.

- For TLX Pro+, via the web interface, navigate to:
  [Plant level: Setup→Grid management]
- For TLX+ via the service web interface, navigate to:
  [Inverter level: Setup→Grid management]
- Via CLX monitoring and grid management product or third-party device: see manual from external device supplier.

### 9.5.3 Remotely Controlled Adjustment of Reactive Power

All inverters support remotely controlled adjustment of reactive power.

**TLX Pro+**

When using the master functionality of the TLX Pro+ inverter to manage the control of reactive power, the Danfoss CLX GM is needed as interface device between the DNO signal interface (radio receiver) and the master inverter. The master inverter uses the DNO signal information to determine the requested reactive power commanded by the DNO and communicates this to the followers in the network. For more information, see the *Danfoss CLX GM User Manual*.

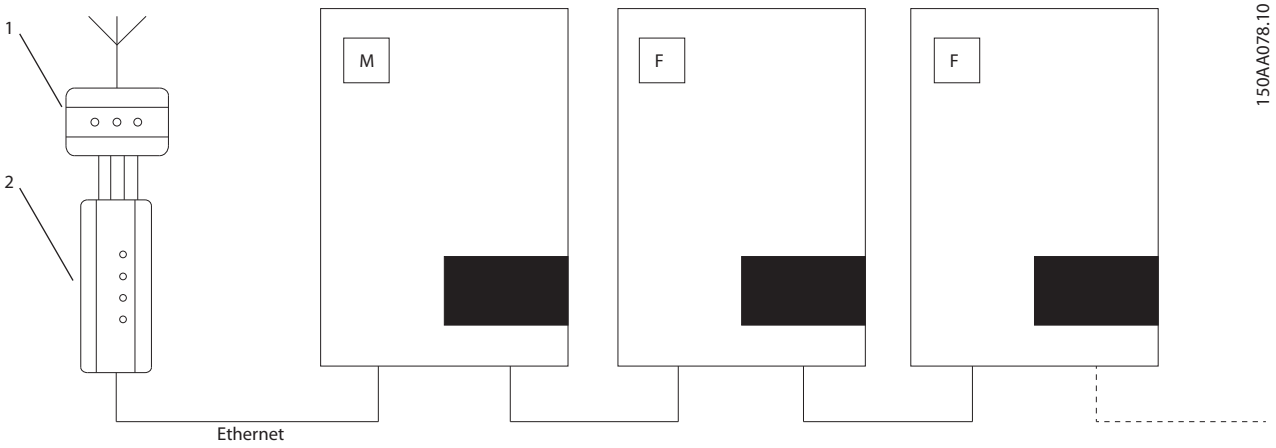


**Illustration 9.9 Example: Managing Power Using TLX Pro and TLX Pro+**

| | |
|---|---|
| 1 | DNO interface (radio receiver) |
| 2 | Danfoss CLX GM |

**Table 9.7 Legend to *Illustration 9.9***

TLX+ with CLX monitoring and grid management product or third-party device

Based on the input from a DNO signal interface, an external device sends reactive power commands directly to the inverter via the RS-485 interface. Each inverter then uses this information to determine its reactive power level. Both Danfoss and third-party products are available for external control. For more information about relevant products, see the supplier manuals.

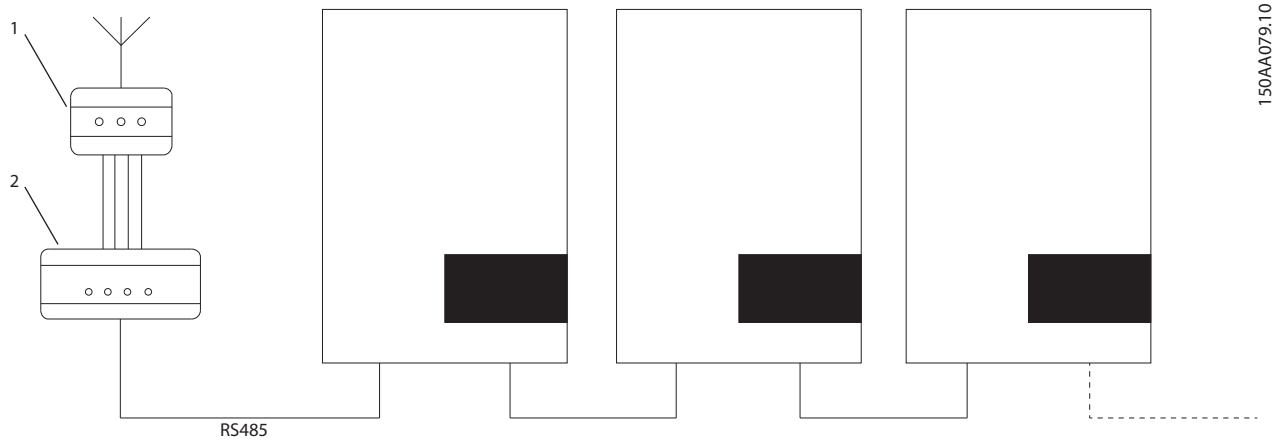


**Illustration 9.10 Example: Managing Power Using External Device**

| | |
|---|---|
| 1 | DNO interface (radio receiver) |
| 2 | CLX monitoring and grid management product or third-party device |

**Table 9.8 Legend to *Illustration 9.10***

**Configuration**
Remotely controlled reactive power is configured in the CLX monitoring and grid management product or third-party device: see manual for CLX monitoring and grid management product or third-party device. Access at security level 1 is required.

- For TLX Pro+, via the web interface, navigate to: [Inverter level: Setup→Grid Management]

## 9.6 Fallback Values

When remotely controlled active power or reactive power is selected as reference value for the inverter, fixed fallback values can be used in the event of communication failure:

- between the master inverter and the Danfoss CLX GM, or
- between the master inverter and the follower inverter

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**Configuration**
To configure fallback values, access at security level 1 is required.

- For TLX Pro / TLX Pro+, navigate to: [Plant level: Grid management → Fallback values]

# 10 Service and Repair

## 10.1 Troubleshooting

To quickly diagnose an error affecting an inverter, go to the Log menu and enter the Eventlog menu. The latest event registered by the inverter, as well as a list of the 20 most recent events, is shown here. When the inverter enters *On grid* mode, the most recent event is cleared and is shown as 0.

The event code is made up of 2 elements:

1. Group classifier - describes the general type of the event
2. Event ID - identifies the specific event

*12 Appendix A - Event List* contains an overview of all events including suggested actions.

The status menu contains many useful sensor read-outs, which may be helpful in diagnosing the exact problem. Review the contents of the status menu to obtain an overview of these read-outs.

## 10.2 Maintenance

Normally, the inverter needs no maintenance or calibration. Ensure the heatsink at the rear of the inverter is not covered. Clean the contacts of the PV load switch once per year. Perform cleaning by cycling the switch to on and off positions ten times.The PV load switch is located at the base of the inverter.

### 10.2.1 Cleaning the Cabinet

Clean the inverter cabinet using pressurised air, a soft cloth or a brush.

### 10.2.2 Cleaning the Heatsink

Clean the heatsink using pressurised air, a soft cloth or a brush.
For correct operation and long service life, ensure free air circulation

- around the heatsink at the rear of the inverter
- to the fan at the inverter base

**⚠WARNING**

**Do not touch the heatsink during operation.**
**Temperature can exceed 70 °C.**

**NOTE**

**Do not cover the inverter.**
**Do not use a water hose, aggressive chemicals, cleaning solvents or strong detergents to clean the inverter.**

# 11 Technical Data

## 11.1 General Data

| Nomenclature[1)] | Parameter | TLX Series 6k | TLX Series 8k | TLX Series 10k | TLX Series 12.5k | TLX Series 15k |
|---|---|---|---|---|---|---|
| | **AC** | | | | | |
| \|S\| | Rated apparent power | 6000 VA | 8000 VA | 10000 VA | 12500 VA | 15000 VA |
| $P_{ac,r}$ | Rated active power[*)] | 6000 W | 8000 W | 10000 W | 12500 W | 15000 W |
| | Active power at cos(phi) = 0.95[**)] | 5700 W | 7600 W | 9500 W | 11875 W | 14370 W |
| | Active power at cos(phi) = 0.90[**)] | 5400 W | 7200 W | 9000 W | 11250 W | 13500 W |
| | Reactive power range | 0-3.6 kVAr | 0-4.8 kVAr | 0-6.0 kVAr | 0-7.5 kVAr | 0-9.0 kVAr |
| $V_{ac,r}$ | Rated grid voltage (range) | 3P + N + PE - 230 V / 400 V (± 20%) | | | | |
| | Rated current AC | 3 x 8.7 A | 3 x 11.6 A | 3 x 14.5 A | 3 x 18.1 A | 3 x 21.7 A |
| $I_{acmax}$ | Max. current AC | 3 x 9.0 A | 3 x 11.9 A | 3 x 14.9 A | 3 x 18.7 A | 3 x 22.4 A |
| | AC current distortion (THD %) | < 4% | | < 5% | | |
| $cosphi_{ac,r}$ | Power factor at 100% load | > 0.99 | | | | |
| | Controlled power factor range | 0.8 over-excited<br>0.8 under-excited | | | | |
| | Power loss, *Connecting mode* | 10 W | | | | |
| | Night-time power loss (off grid) | < 5 W | | | | |
| $f_r$ | Grid frequency (range) | 50 Hz (± 5 Hz) | | | | |
| | **DC** | | | | | |
| $P_{mpptmax}$ | Maximum PV input power per MPPT | 8000 W | | | | |
| $\Sigma P_{mpptmax}$ | Max./nom. converted PV input power, total | 6200 W | 8250 W | 10300 W | 12900 W | 15500 W |
| $V_{dc,r}$ | Nominal rated voltage DC | 700 V | | | | |
| $V_{mppmin}$ - $V_{mppmax}$ | MPP voltage - nominal power [2)] | 260-800 V | 345-800 V | 430-800 V | 358-800 V | 430-800 V |
| | MPP efficiency, static | 99.9% | | | | |
| | MPP efficiency, dynamic | 99.7% | | | | |
| $V_{dcmax}$ | Max. DC voltage | 1000 V | | | | |
| $V_{dcstart}$ | Turn on voltage DC | 250 V | | | | |
| $V_{dcmin}$ | Turn off voltage DC | 250 V | | | | |
| $I_{dcmax}$ | Max. current DC | 2 x 12 A | | | 3 x 12 A | |
| | Max. short circuit current DC at STC | 2 x 12 A | | | 3 x 12 A | |
| | Min. on grid power | 20 W | | | | |
| | **Efficiency** | | | | | |
| | Max. efficiency | 97.8% | 97.9% | 98.0% | | |

| Nomenclature[1)] | Parameter | TLX Series 6k | TLX Series 8k | TLX Series 10k | TLX Series 12.5k | TLX Series 15k |
|---|---|---|---|---|---|---|
| | Euro efficiency, V at $_{dc,r}$ | 96.5% | 97.0% | 97.0% | 97.3% | 97.4% |
| | **Other** | | | | | |
| | Dimensions (H,W,D) | 700 x 525 x 250 mm | | | | |
| | Mounting | Wall bracket | | | | |
| | Weight | 35 kg | | | | |
| | Acoustic noise level | 56 dB(A) | | | | |
| | MPP trackers | 2 | | | 3 | |
| | Operation temperature range | -25..60 °C | | | | |
| | Nom. temperature range | -25..45 °C | | | | |
| | Storage temperature | -25..60 °C | | | | |
| | Overload operation | Change of operating point | | | | |
| | Active power control[3)] | Included | | | | |
| | Reactive power control | TLX+ and TLX Pro+ | | | | |

**Table 11.1 General Specifications**

*1) According to FprEN 50524 where relevant.*

*2) At identical input voltages. At unequal input voltages, $V_{mppmin}$ can be as low as 250 V depending on total input power.*

*3) Remotely controlled via CLX monitoring and grid management product or third-party device.*

**) At rated grid voltage ($V_{ac,r}$), Cos(phi) = 1.*

***) At rated grid voltage ($V_{ac,r}$).*

| Parameter | TLX Series | |
|---|---|---|
| **Functional Safety** | **Passive** | **Active AC disconnection** |
| Safety (protective class) | Class I | |
| PELV on the communication and control card | Class II | |
| Islanding detection - loss of mains | | Three-phase monitoring ROCOF |
| Voltage magnitude | | Included |
| Frequency | | Included |
| Insulation resistance | | Included |
| RCMU - Type B | | Included |
| Indirect contact protection | Yes (class I, grounded) | |

**Table 11.2 Functional Safety Specifications**

## 11.2 Norms and Standards

| Normative References | TLX Series | | | | |
|---|---|---|---|---|---|
| | 6k | 8k | 10k | 12.5k | 15k |
| Directive LVD | 2006/95/EC | | | | |
| Directive EMC | 2004/108/EC | | | | |
| Safety | IEC 62109-1/IEC 62109-2 | | | | |
| Integrated PV load switch | VDE 0100-712 | | | | |
| EMC immunity | EN 61000-6-1 | | | | |
| | EN 61000-6-2 | | | | |
| EMC emission | EN 61000-6-3 | | | | |
| | EN 61000-6-4 | | | | |
| Utility interference | EN 61000-3-2/-3 | | | EN 61000-3-11/-12 | |
| CE | Yes | | | | |
| Utility characteristics | IEC 61727 | | | | |
| | EN 50160 | | | | |
| S0 Energy Meter | EN62053-31 Annex D | | | | |
| **Functional Safety** | **For transformerless inverter** | | | | |
| Germany | VDE 0126-1-1/A1[1)] | | | | |
| | VDE AR-N 4105 (August 2011)[2)] | | | | |
| Greece | Technical requirements for the connection of independent generation to the grid, Public Power Corporation (PPC). | | | | |
| Italy | - | CEI 0-21:2012-06, Terna Guida Tecnica Allegato A.70[2)] | | | |
| Spain | RD1699 (2011) | | | | |
| | RD661 (2007) | | | | |
| Portugal | VDE 0126-1-1, ISO/IEC Guide 67: 2004 - System No.5 | | | | |
| UK | - | G59/2-1, G83/1-1 | | G59/2-1 | |
| **Ancillary Services** | **TLX Series** | | | | |
| | **TLX+ and TLX Pro+** | | | | |
| | **6k** | **8k** | **10k** | **12.5k** | **15k** |
| Austria | TOR – Hauptabschnitt D4, TOR – Hauptabschnitt D2 | | | | |
| Belgium | Synergrid C10/11 – Revisie 2012-06, Synergrid C10/17- revisie 8 mei 2009 | | | | |
| Czech Republic | Czech Energy Act (Act No. 458/2000), Article 24, Paragraph 10 part I,II,III rev09 2009 | | | | |
| France | UTE NF C 15-712-1 (UNION TECHNIQUE DE L'ELECTRICITE, GUIDE PRATIQUE, Installations photovoltaïques raccordées au réseau public de distribution).<br>NF C 15-100 (Installations électriques à basse tension).<br>Journal Officiel, Décret n°2008-386 du 23 avril 2008 relatif aux prescriptions techniques générales de conception et de fonctionnement pour le raccordement d'installations de production aux réseaux publics d'électricité. | | | | |
| Germany | - | BDEW- Technische Richtlinie Erzeugungsanlagen am Mittelspannungsnetz Ausgabe, Juni 2008 und Ergänzungen von 01/2009, 07/2010, 02/2011[2)] | | | |
| Spain | REE BOE núm. 254 | | | | |

**Table 11.3 Norms and Standards**

*1) Deviant from VDE 0126-1-1 section 4.7.1, the isolation resistance measurement limit is set to 200 kΩ, in accordance with authorities.*

*2) TLX+ and TLX Pro+ only.*

## 11.3 France UTE Requirements

### NOTE

**In France, observe the UTE C 15-712-1 and NF C 15-100 requirements.**

For installation in France, apply warning label to front of inverter.

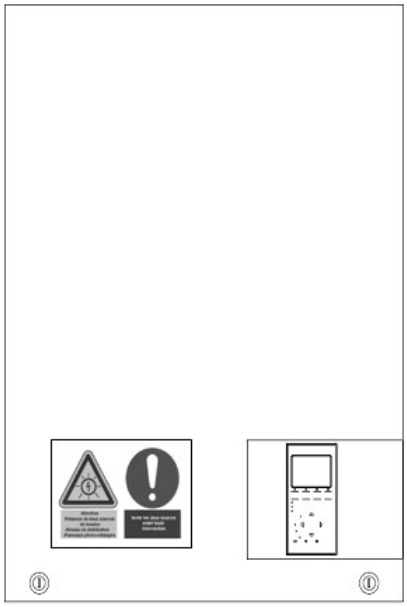

**Illustration 11.1 Position of Warning Label**

| Parameter | Condition | Specification |
|---|---|---|
| Wall Plate | Hole diameter | 30 x 9 mm |
| | Alignment | Perpendicular ± 5° all angles |

**Table 11.5 Wall Plate Specifications**

## 11.4 Installation

| Parameter | Specification |
|---|---|
| Temperature | −25 °C - +60 °C (>45 °C derating) |
| Environmental class according to IEC | IEC60721-3-3<br>3K6/3B3/3S3/3M2 |
| Air quality - general | ISA S71.04-1985<br>Level G2 (at 75% RH) |
| Air quality - coastal, heavy industrial and agricultural zones | Must be measured and classified acc. to ISA S71.04-1985 |
| Vibration | 1G |
| Ingress protection class | 54 |
| Max. operating altitude | 3000 m above sea level.<br>PELV protection is effective up to 2000 m above sea level only. |
| Installation | Avoid constant stream of water.<br>Avoid direct sunlight.<br>Ensure adequate air flow.<br>Mount on non-flammable surface.<br>Mount upright on vertical surface.<br>Prevent dust and ammonia gases. |

**Table 11.4 Conditions for Installation**

## 11.5 Torque Specifications for Installation

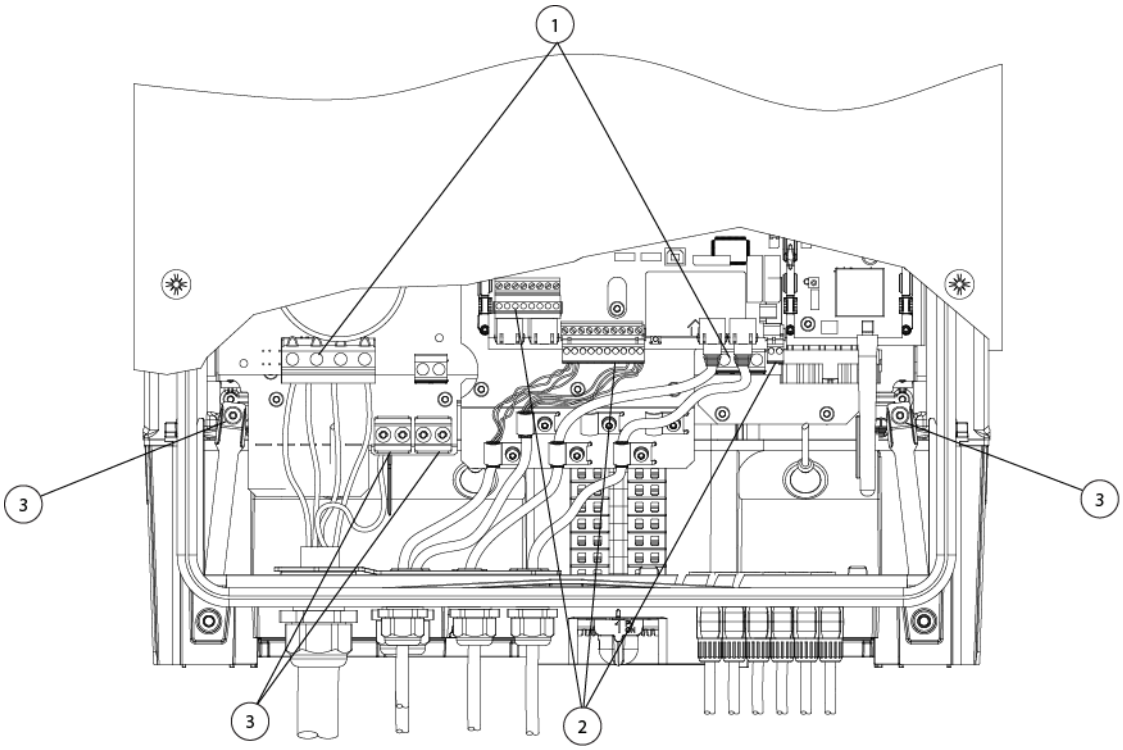


**Illustration 11.2 Overview of Inverter with Torque Indications, 1-3**

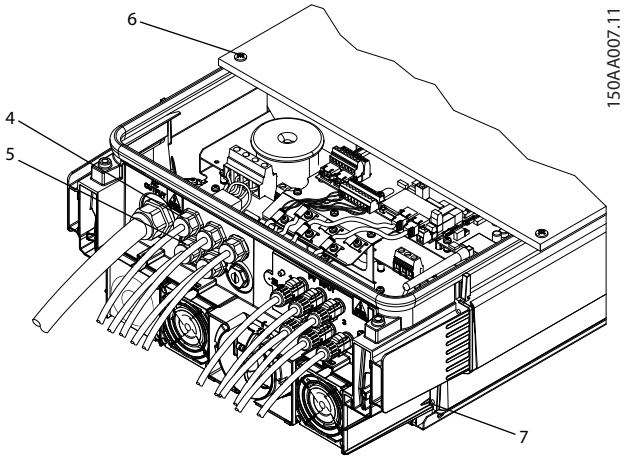


**Illustration 11.3 Overview of Inverter with Torque Indications, 4-7**

| | Parameter | Tool | Tightening Torque |
|---|---|---|---|
| 1 | Terminal blocks (large) | Straight slot 1.0 x 5.5 mm | Min. 1.2 Nm |
| 2 | Terminal blocks (small) | Straight slot 1.0 x 5.5 mm | 0.5 Nm |
| 3 | PE | Straight slot 1.0 x 5.5 mm | 2.2 Nm |
| 4 | M16 | SW 19 mm | 2-3 Nm |
| 5 | M25 | SW 30 mm | 2-3 Nm |
| 6 | Front screw | TX 30 | 6-8 Nm |
| 7 | Locking screw | TX 30 | 5 Nm |

**Table 11.6 Legend to *Illustration 11.2* and *Illustration 11.3*, Nm Specifications**

## 11.6 Mains Circuit Specifications

| | TLX Series | | | | |
|---|---|---|---|---|---|
| | 6k | 8k | 10k | 12.5k | 15k |
| Maximum inverter current, $I_{acmax.}$ | 9.0 A | 11.9 A | 14.9 A | 18.7 A | 22.4 A |
| Recommended blow fuse type gL/gG | 13 A | 16 A | 20 A | 20 A | 25 A |
| Recommended automatic fuse type B | 16 A | 20 A | 20 A | 25 A | 32 A |

**Table 11.7 Mains Circuit Specifications**

## 11.7 Auxiliary Interface Specifications

| Parameter | Parameter Details | Specification |
|---|---|---|
| **Serial Communication** | | **RS-485** |
| Common cable specification | Cable jacket diameter (⌀) | 2 x 5-7 mm |
| | Cable type | Shielded Twisted Pair (STP) (Cat 5e)[2] |
| | Cable Characteristic Impedance | 100 Ω – 120 Ω |
| | Max. cable length | 1000 m |
| RJ-45 (2 pcs.) connectors | Wire gauge | 24-26 AWG (depending on mating metallic RJ-45 plug) |
| | Cable shield termination | Via metallic RJ-45 plug |
| Terminal block | Maximum wire gauge | 2.5 $mm^2$ |
| | Cable shield termination | Via EMC cable clamp |
| Max. number of inverter nodes | | 63[4] |
| Galvanic interface insulation | | Yes, 500 Vrms |
| Direct contact protection | Double/Reinforced insulation | Yes |
| Short-circuit protection | | Yes |
| Communication | Star and daisy chain | **Ethernet** |
| Common cable | Max. cable length between inverters | 100 m (total network length: unlimited) |
| Specification | Max. number of inverters | 100[1] |
| | Cable type | Shielded Twisted Pair (STP) (Cat 5e)[2] |
| **Temperature sensor input** | | **3 x PT1000** [3] |
| Cable specification | Cable jacket diameter (⌀) | 4-8 mm |
| | Cable type | Shielded Single Pair - 2-wire |
| | Cable shield termination | Via EMC cable clamp |
| | Maximum wire gauge | 2.5 $mm^2$ |
| | Maximum resistance per wire | 10 Ω |
| | Maximum cable length | 30 m |
| Sensor specification | Nominal resistance/temperature coefficient | 3.85 Ω/ºC |
| | Measurement range | -20 ºC - +100 ºC |
| | Measurement accuracy | ±3% |
| Direct contact protection | Double/Reinforced insulation | Yes |
| Short-circuit protection | | Yes |
| **Irradiation sensor input** | | **x 1** |

| Parameter | Parameter Details | Specification |
|---|---|---|
| Cable specification | Cable jacket diameter (⌀) | 4-8 mm |
| | Cable type | Shielded Single Pair - Number of wires depend on the sensor type used |
| | Cable shield termination | Via EMC cable clamp |
| | Maximum wire gauge | 2.5 $mm^2$ |
| | Maximum resistance per wire | 10 Ω |
| | Maximum cable length | 30 m |
| Sensor Specification | Sensor type | Passive |
| | Measurement accuracy | ±5% (150 mV sensor output voltage) |
| | Output voltage of sensor | 0-150 mV |
| | Max. output impedance (sensor) | 500 Ω |
| | Input impedance (electronics) | 22 kΩ |
| Direct contact protection | Double/Reinforced insulation | Yes |
| Short-circuit protection | | Yes |
| **Energy meter input** | **S0 input** | **x 1** |
| Cable specification | Cable jacket diameter (⌀) | 4-8 mm |
| | Cable type | Shielded Single Pair - 2-wire |
| | Cable shield termination | Via EMC cable clamp |
| | Maximum wire gauge | 2.5 $mm^2$ |
| | Maximum cable length | 30 m |
| Sensor Input Specification | Sensor input class | Class A |
| | Nominal output current | 12 mA for an 800 Ω load |
| | Maximum short-circuit output current | 24.5 mA |
| | Open-circuit output voltage | +12 VDC |
| | Maximum pulse frequency | 16.7 Hz |
| Direct contact protection | Double/Reinforced insulation | Yes |
| Short-circuit protection | | Yes |

**Table 11.8 Auxiliary Interface Specifications**

*[1] A maximum of 100 inverters can be connected in 1 network. If GSM modem is used for portal upload, the number of inverters in a network is limited to 50.*

*[2] For underground use, outdoor burial type cable is recommended for both Ethernet and RS-485.*

*[3] Third input is used for compensation of the irradiation sensor.*

*[4] The number of inverters to be connected in the RS-485 network depends on which peripheral device is connected.*

**⚠CAUTION**

**To ensure fulfilment of IP enclosure rating, correctly mounted cable glands are essential for all peripheral cables.**

**⚠CAUTION**

**To ensure EMC compliance, shielded cables must be applied for sensor inputs and RS-485 communication. Unshielded cables may be applied for alarm outputs. Other auxiliary cables must pass through the designated EMC cable clamps to establish mechanical fixing and in case of shielded cable termination to the shielding device.**

| Parameter | Condition | Specification |
|---|---|---|
| Potential free contact | Relay output | x 1 |
| Rating AC | | 250 V AC, 6.4 A, 1600 W |
| Rating DC | | 24 V DC, 6.4 A, 153 W |
| Maximum wire gauge | | 2.5 $mm^2$ |
| Overvoltage category | | Class III |
| Modem | | GSM |

**Table 11.9 Auxiliary Input Specifications**

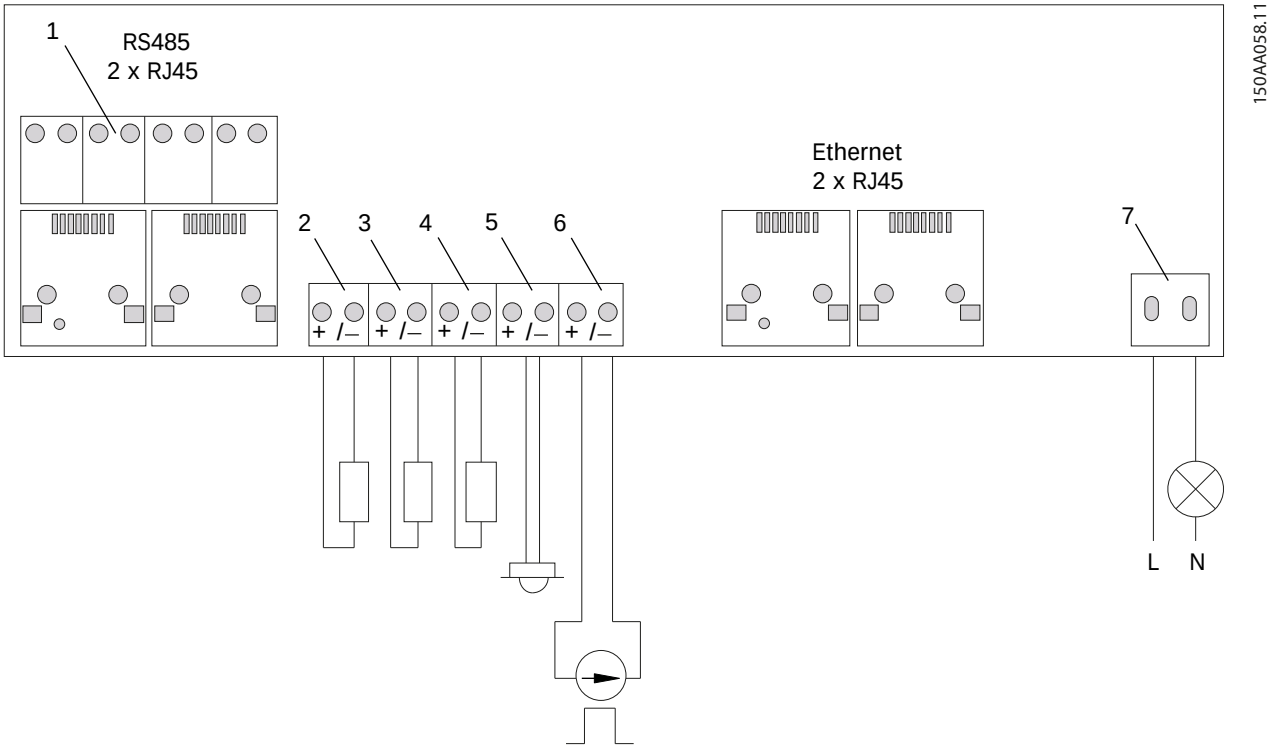


**Illustration 11.4 Communication Board**

| | |
|---|---|
| 1 | 8-pole terminal blocks |
| 2 | PT1000/module temp. |
| 3 | PT1000/ambient temp. |
| 4 | PT1000/irradiation sensor temp. |
| 5 | Irradiation sensor |
| 6 | S0/Energy meter |
| 7 | Relay 1 |

**Table 11.10 Legend to *Illustration 11.4***

### RS-485

Terminate the RS-485 communication bus at both ends.
To terminate the RS-485 bus:

- Connect Bias H to RX/TX B
- Connect Bias L to RX/TX A

The RS-485 address of the inverter is unique, and defined at the factory.

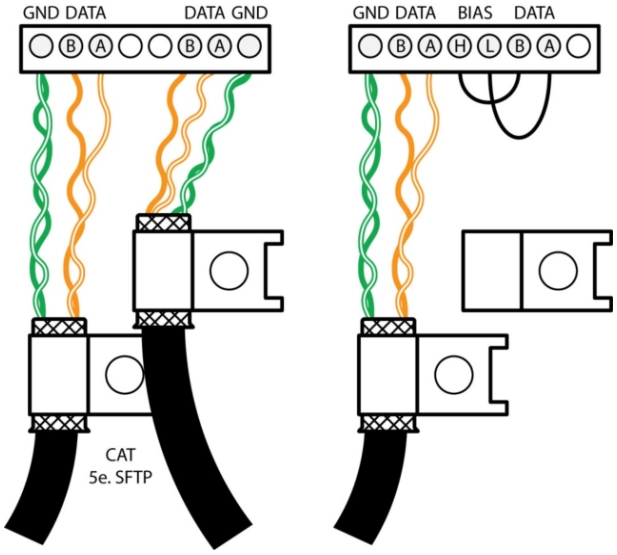


**Illustration 11.5 RS-485 Communication Detail - Cat 5 T-568A**

11

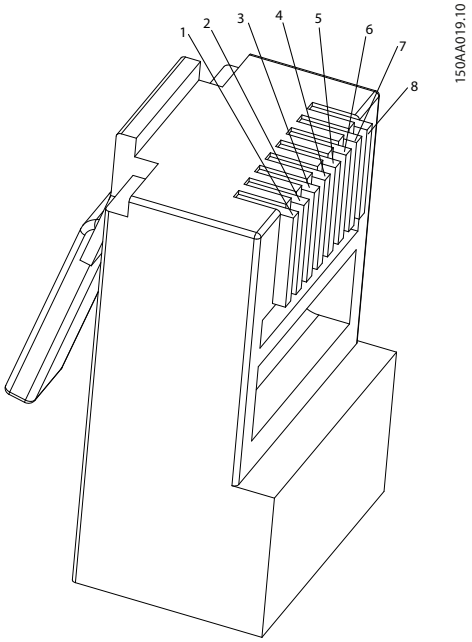


Illustration 11.6 RJ-45 Pinout Detail for RS-485

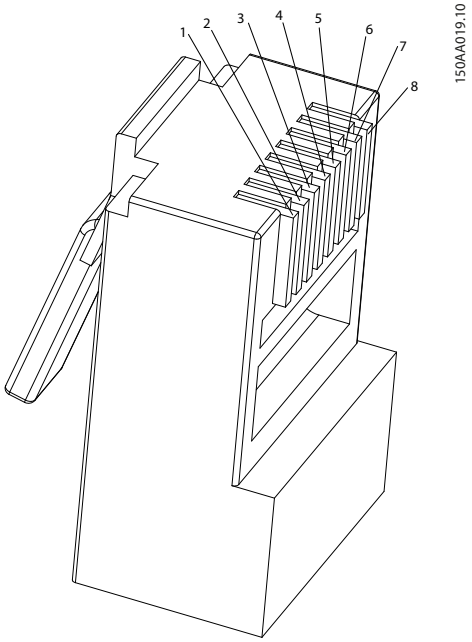


Illustration 11.7 RJ-45 Pinout Detail for Ethernet

| | |
|---|---|
| 1 | **GND** |
| 2 | GND |
| 3 | **RX/TX A (-)** |
| 4 | BIAS L |
| 5 | BIAS H |
| 6 | **RX/TX B (+)** |
| 7 | Not connected |
| 8 | Not connected |

**Table 11.11 Legend to *Illustration 11.6***

***Bold**=Compulsory, Cat5 cable contains all 8 wires*
*For Ethernet: 10Base-TX and 100Base-TX auto cross over*

**Ethernet**
Ethernet connection is available for TLX Pro and TLX Pro+ variants only.

| | **Colour Standard** | | |
|---|---|---|---|
| | **Pinout Ethernet** | **Cat 5 T-568A** | **Cat 5 T-568B** |
| 1 | RX+ | Green/white | Orange/white |
| 2 | RX | Green | Orange |
| 3 | TX+ | Orange/white | Green/white |
| 4 | | Blue | Blue |
| 5 | | Blue/white | Blue/white |
| 6 | TX- | Orange | Green |
| 7 | | Brown/white | Brown/white |
| 8 | | Brown | Brown |

**Table 11.12 Legend to *Illustration 11.7***

## 11.7.1 Network Topology

The inverter has two Ethernet RJ-45 connectors enabling the connection of several inverters in a line topology as an alternative to the typical star topology. The two ports are similar and may be used interchangeably. For RS-485, only linear daisy chain connections can be used.

## NOTE

**Ring topology is not allowed.**

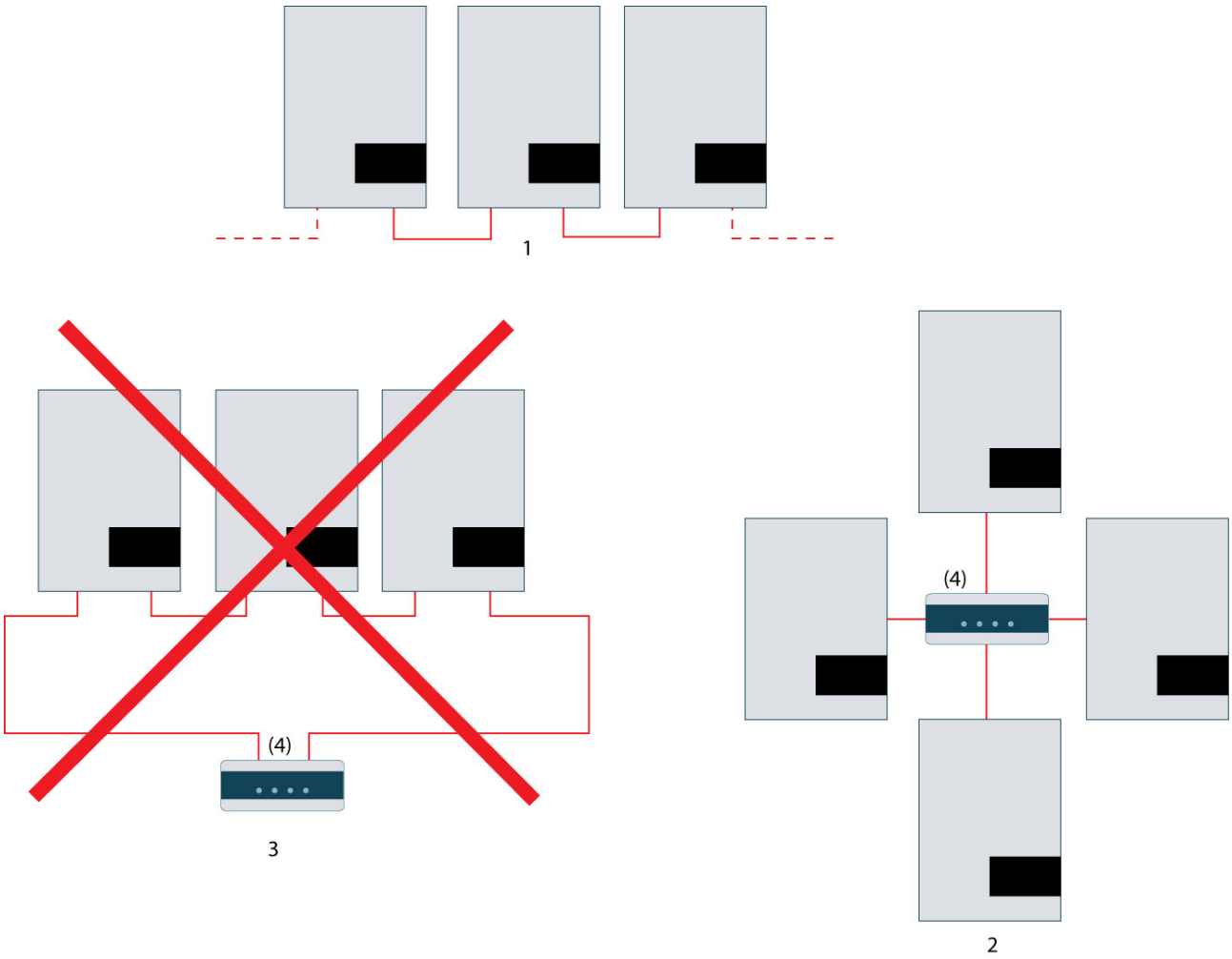


Illustration 11.8 Network Topology

| | |
|---|---|
| 1 | Linear Daisy Chain |
| 2 | Star Topology |
| 3 | Ring Topology (not allowed) |
| (4) | (Ethernet Switch) |

Table 11.13 Legend to *Illustration 11.8*

## NOTE

The two network types cannot be mixed. The inverters can only be connected in networks which are either solely RS-485 or solely Ethernet.

## NOTE

Ethernet connection is recommended for faster communication.
RS-485 connection is required when a web logger or data logger is connected to the inverter, or via CLX monitoring and grid management product or third-party device.

# 12 Appendix A - Event List

## 12.1.1 How to Read the Event List

The Event List holds an action field for each event, or the categorised group of events. The 'Action' field should be understood as progressive steps and recommendations as follows:

- Step 1: End User
- Step 2: Installer
- Step 3: Service

## 12.1.2 Grid Events

| Event ID 1-6 | Display Text | Action |
|---|---|---|
| **Description:**<br>Grid voltage too low | *UgridRmsLowS2L1*<br>*UgridRmsLowS2L2*<br>*UgridRmsLowS2L3*<br>*UgridRmsLowS1L1*<br>*UgridRmsLowS1L2*<br>*UgridRmsLowS1L3*<br>*)<br>S1 = STAGE 1<br>S2 = STAGE 2<br>L1 = PHASE 1<br>L2 = PHASE 2<br>L3 = PHASE 3 | **End user:**<br>Call the installer and inform about the grid-phase voltage.<br>• Voltage on corresponding phase is OK:<br>- Wait 10 minutes on phase L1, L2 and/or L3 to see if the inverter reconnects to the grid<br>- If the event reappears on site, service is needed<br>**Installer:**<br>Check the AC installation<br>• Check all fuses and the RCD/RCMU<br>- All OK – call service<br>**Service:**<br>Exchange the inverter. |

| Event ID 7-9 | Display Text | Action |
|---|---|---|
| **Description:**<br>Grid-voltage average over 10 min. too high | *UGRID_RMS_10MINAVG_HIGH_L1*<br>*UGRID_RMS_10MINAVG_HIGH_L2*<br>*UGRID_RMS_10MINAVG_HIGH_L3* | **End user:**<br>Call the installer and inform about the grid-phase voltage.<br>• Voltage on corresponding phase is OK:<br>- Wait 10 minutes on phase L1, L2 and/or L3 to see if the inverter reconnects to the grid<br>- If the event reappears on site, service is needed<br>**Installer:**<br>Mitigation possibilities:<br>• Install cable of larger diameter (to reduce the voltage drop) between inverter and meter<br>• Program PF(P) – TLX+ and TLX Pro+ only<br>• Call DNO to get permission to increase limit (note: Ugrid_RMS_high)<br>Use installation tester to test resistance in the installation (phase-neutral)<br>**Service:**<br>None. |

| Event ID 10-15 | Display Text | Action |
|---|---|---|
| **Description:**<br>Grid voltage too high | *UGRID_RMS_HIGH_S1_L1*<br>*UGRID_RMS_HIGH_S1_L2*<br>*UGRID_RMS_HIGH_S1_L3*<br>*UGRID_RMS_HIGH_S2_L1*<br>*UGRID_RMS_HIGH_S2_L2*<br>*UGRID_RMS_HIGH_S2_L3*<br>*)<br>S1 = STAGE 1<br>S2 = STAGE 2<br>L1 = PHASE 1<br>L2 = PHASE 2<br>L3 = PHASE 3 | **End user:**<br>Call the installer and inform about the grid-phase voltage.<br>• Voltage on phase 1 is OK:<br>- Wait 10 minutes on phase L1, L2 and/or L3 to see if the inverter reconnects to the grid<br>- If the event reappears on site, service is needed<br>**Installer:**<br>Measure the grid voltage:<br>• OK – call service<br>• Not OK – call the DNO for a resolution<br>**Service:**<br>Exchange the inverter. |

| Event ID 16-18 | Display Text | Action |
|---|---|---|
| **Description:**<br>The inverter has detected a voltage peak on the grid. | *UGRID_INSTANTANIOUS_HIGH_L1*<br>*UGRID_INSTANTANIOUS_HIGH_L2*<br>*UGRID_INSTANTANIOUS_HIGH_L3* | **End user:**<br>Call the installer and inform about the grid-phase voltage.<br>• Voltage on phase 1 is OK:<br>- Wait 10 minutes on phase L1, L2 and/or L3 to see if the inverter reconnects to the grid<br>- If the event reappears on site, service is needed<br>**Installer:**<br>Check the AC installation (all fuses and the RCD):<br>• OK – call service<br>**Service:**<br>Exchange the inverter. |

| Event ID<br>19-24, 48-53 | Display Text | Action |
|---|---|---|
| **Description:**<br>Grid frequency too low or too high | *FGRID_LOW_S1_L1*<br>*FGRID_LOW_S1_L2*<br>*FGRID_LOW_S1_L3*<br>*FGRID_HIGH_S1_L1*<br>*FGRID_HIGH_S1_L2*<br>*FGRID_HIGH_S1_L3* | **End user:**<br>Call the installer and inform about the grid frequency.<br>• Frequency is OK:<br>- Wait 10 minutes to see if the inverter reconnects to the grid.<br>- If the event reappears on site, service is needed<br>**Installer:**<br>Check the AC installation (all fuses and the RCD):<br>• OK – call service<br>**Service:**<br>Exchange the inverter. |

| Event ID 25-27 | Display Text | Action |
|---|---|---|
| **Description:**<br>Phase-to-phase voltages too low | *LOM_LINETOLINE_LOW_L1*<br>*LOM_LINETOLINE_LOW_L2*<br>*LOM_LINETOLINE_LOW_L3* | **End user:**<br>Call the installer and inform about the voltage on all three phases.<br>• Voltages are OK:<br>- Wait 10 minutes to see if the inverter reconnects to the grid<br>- If the event reappears on site, service is needed<br>**Installer:**<br>Check the AC installation (all fuses and the RCD):<br>• OK – call service<br>**Service:**<br>Exchange the inverter. |

| Event ID 28-30 | Display Text | Action |
|---|---|---|
| **Description:**<br>Rate Of Change Of Frequency (ROCOF) too high | *LOM_ROCOF_HIGH_L1*<br>*LOM_ROCOF_HIGH_L2*<br>*LOM_ROCOF_HIGH_L3* | **End user:**<br>If the event reoccurs several times each day, contact the DNO.<br>**Installer:**<br>None.<br>**Service:**<br>None. |

| Event ID<br>31-33, 44-46 | Display Text | Action |
|---|---|---|
| **Description:**<br>DC grid current too high | *IGRID_DC_CURRENT_HIGH_L1S1*<br>*IGRID_DC_CURRENT_HIGH_L2S2*<br>*IGRID_DC_CURRENT_HIGH_L3S3*<br>*IGRID_DC_CURRENT_HIGH_STEP_L1*<br>*IGRID_DC_CURRENT_HIGH_STEP_L2*<br>*IGRID_DC_CURRENT_HIGH_STEP_L3* | **End user:**<br>Check SW version [Status]<br>• If SW version 2.15, 1.12 or older, a SW update is required. Call the installer.<br>**Installer:** Install newest SW. version<br>**Service:**<br>None. |

| Event ID 34-37 | Display Text | Action |
|---|---|---|
| **Description:**<br>Residual Current Monitoring Unit (RCMU) has measured an excessive current | *IRESIDUAL_HIGH*<br>*IRESIDUAL_STEP_S3_HIGH*<br>*IRESIDUAL_STEP_S2_HIGH*<br>*IRESIDUAL_STEP_S1_HIGH* | **End user:**<br>Turn both DC and AC off and wait until the display turns off. Then turn on DC and AC and observe if the event reoccurs. If the event reoccurs, call the installer.<br>**Installer:**<br>Check the PV installation. If OK, call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 40 | Display Text | Action |
|---|---|---|
| **Description:**<br>AC grid out of spec for more than 10 minutes (frequency and/or voltage) | *GRID_DURING_CONNECT* | **End user:**<br>Call the installer and inform about:<br>• Frequency<br>Display: [Status → Inverter → AC grid → Present value]<br>• Voltage<br>Display: [Status → Inverter → AC grid → Present value]<br>• SW version<br>Display: [Status → Inverter → Serial no. and SW version → Inverter]<br>• Grid code setting (eg. “Germany LV 1”)<br>Display [Status → Inverter]<br>**Installer:**<br>If SW version is 2.15 or older, an update is needed.<br>Check the log for other events.<br>Check the AC installation.<br>**Service:**<br>None. |

| Event ID 41-43 | Display Text | Action |
|---|---|---|
| **Description:**<br>The inverter has detected that grid voltage was below a certain level | *FAULT_RIDE_THROUGH_L1*<br>*FAULT_RIDE_THROUGH_L2*<br>*FAULT_RIDE_THROUGH_L3* | **End user:**<br>If this event is reported several times each day, contact the installer.<br>**Installer:**<br>Perform on-site grid analysis.<br>**Service:**<br>None. |

| Event ID 47-48 | Display Text | Action |
|---|---|---|
| **Description:**<br>The inverter disconnects from grid if PLA is below 3% of nominal power | *PLA_BELOW_THRESHOLD* | **End user:**<br>Contact the DNO and obtain status on active power reduction (PLA).<br>**Installer:**<br>None.<br>**Service:**<br>None. |

| Event ID 54-56, | Display Text | Action |
|---|---|---|
| **Description:**<br>DC grid current too high (stage 2) | *IGRID_DC_CURRENT_HIGH_L1S2*<br>*IGRID_DC_CURRENT_HIGH_L2S2*<br>*IGRID_DC_CURRENT_HIGH_L3S2* | **End user:**<br>If this event is reported several times each day, contact the installer.<br>**Installer:**<br>Perform on-site grid analysis.<br>**Service:**<br>None. |

## 12.1.3 PV Events

| Event ID 100-102 | Display Text | Action |
|---|---|---|
| **Description:**<br>The input current is negative; the polarity of the PV string is wrong. Should only appear during or immediately after installation or service | *IPV_NEGATIVE_PV1*<br>*IPV_NEGATIVE_PV2*<br>*IPV_NEGATIVE_PV3* | **End user:**<br>Call the installer.<br>**Installer:**<br>• Is the polarity of the PV strings reversed (e.g. PV plus-wire connected with inverter minus-input)?<br>• If not, call service<br>**Service:** Exchange the inverter. |

| Event ID 103-105 | Display Text | Action |
|---|---|---|
| **Description:**<br>The input current is too high. Too many PV modules connected in parallel. Should only appear on newly installed systems | *IPV_HIGH_PV1*<br>*IPV_HIGH_PV2*<br>*IPV_HIGH_PV3* | **End user:**<br>Call the installer.<br>**Installer:**<br>Check PV installation<br>• How many strings are in parallel? What are their current ratings? Has the 12 A input limit been exceeded?<br>• Has the inverter derated on PV current [Log → derate, level 1]?<br>If too many strings are in parallel, then fix it by:<br>- connecting the inverter inputs in parallel to distribute the current into the inverter<br>- installing a second inverter<br>**Service:** None. |

| Event ID 115 | Display Text | Action |
|---|---|---|
| **Description:**<br>The resistance between the PV strings and ground is too low for the inverter to start up | *PV_ISO_TOO_LOW* | **End user:**<br>Call the installer and inform about isolation resistance.<br>Display: [Status → Photovoltaic → Isolation resistance].<br>**Installer:**<br>Check minimum recorded isolation resistance [Status → Photovoltaic → Isolation resistance], security level 1 needed<br>• Go through the PV installation and check connectors, cables and modules for insulation-failure.<br>• If the failure is present while on site, disconnect PV input 1 and restart the inverter to locate the affected PV string. Continue with strings 2 and 3.<br>Make a visual inspection of all PV cables and modules. Check that the installation is correct according to the installation manual as this event could indicate that the PE connection is missing.<br>**Service:** None. |

| Event ID 116 | Display Text | Action |
|---|---|---|
| **Description:**<br>Wrong PV polarity | *SELF_TEST_4_6_WRONG_POLARITY* | **End user:**<br>Call the installer.<br>**Installer:**<br>Check whether or not the inverter starts when connecting each PV input separately. Be aware of parallel connections.<br>**Service:** None. |

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## 12.1.4 Internal Events

| Event ID 201-208 | Display Text | Action |
|---|---|---|
| **Description:**<br>Internal temperature is too high | *TPOWER_HIGH_L1*<br>*TPOWER_HIGH_L2*<br>*TPOWER_HIGH_L3*<br>*TPOWER_HIGH_BOOSTER*<br>*TPCB_CTRL_HIGH*<br>*TPCB_COMM_HIG*<br>*TPCB_AUX_HIGH*<br>*TPCB_AUX_POWER* | **End user:**<br>Make sure that the inverter is not covered and that the ventilation duct (heat sink) is not blocked. If not, call the installer.<br>**Installer:**<br>Has the inverter derated on temperature [Log → derate], security level 1 required<br>Has the inverter reported event 211 (fan)?<br>• No: call service.<br>• Yes: clean heatsink / remove obstruction (see description for event 211).<br>**Service:**<br>Exchange the inverter. |

| Event ID 209-210 | Display Text | Action |
|---|---|---|
| **Description:**<br>Voltage on DC bus is too high | *UDC_POS_HIGH*<br>*UDC_NEG_HIGH* | **End user:**<br>Reset the inverter by disconnecting DC and AC, using the switches. If the event is repeated, call the installer.<br>**Installer:**<br>Check whether AC voltage is below max. rating or check the event log to see if other errors have occurred.<br>If AC voltage is too high: wait 10 minutes, then try to reconnect.<br>**Service:**<br>None. |

| Event ID 211 | Display Text | Action |
|---|---|---|
| **Description:**<br>Fan speed is too low | *FAN_RPM_LOW* | **End user:**<br>Is the inverter fan blocked?<br>• Yes: clean the fan<br>• No: call the installer<br>**Installer:**<br>Exchange the fan.<br>**Service:**<br>None. |

| Event ID 212 | Display Text | Action |
|---|---|---|
| **Description:**<br>Inverter unable to balance DC bus | *DCBUS_BALANCE_TIMEOUT* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 213-215 | Display Text | Action |
|---|---|---|
| **Description:**<br>Internal error<br>Voltage measured before and after the relay differs by more than 20 V | *UGRID_UINV_DIFF_HIGH_L1*<br>*UGRID_UINV_DIFF_HIGH_L2*<br>*UGRID_UINV_DIFF_HIGH_L3* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 216-218 | Display Text | Action |
|---|---|---|
| **Description:**<br>Current measured on AC side is too high | *IGRID_HW_TRIP_L1*<br>*IGRID_HW_TRIP_L2*<br>*IGRID_HW_TRIP_L3* | **End user:**<br>Call the installer.<br>**Installer:**<br>If software version is 1.09 or older, update to latest software version. If this does not help, call service.<br>Display: [Status → Inverter → Serial no. and SW version]<br>**Service:**<br>Exchange the inverter. |

| Event ID 223 | Display Text | Action |
|---|---|---|
| **Description:**<br>Replaced by events 255-257 | *IGRID_SUM_HIGH* | **End user:**<br>Call the installer.<br>**Installer:**<br>Update software to latest version.<br>**Service:**<br>None. |

| Event ID 224 | Display Text | Action |
|---|---|---|
| **Description:**<br>Defective RCMU circuit, should also include events 350-352 from self-test (fail safe) | *RCMU_OVERRANGE* | **End user:**<br>Call the installer.<br>**Installer:**<br>If self-test does not complete successfully, call service partner.<br>**Service:**<br>Exchange the inverter. |

| Event ID 225-231 | Display Text | Action |
|---|---|---|
| **Description:**<br>Failure in Memory/ Eeprom | *CTRL_EEPROM_CHECKSUM_ERROR*<br>*COMM_EEPROM_CHECKSUM_ERROR*<br>*AUX_EEPROM_CHECKSUM_ERROR*<br>*POWER_EEPROM_CHECKSUM_ERROR*<br>*CTRL_FLASH_CHECKSUM_ERROR*<br>*COMM_FLASH_CHECKSUM_ERROR*<br>*FSP_FLASH_CHECKSUM_ERROR* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange board or inverter. |

| Event ID 233-240 | Display Text | Action |
|---|---|---|
| **Description:**<br>Memory check failed | *CTRL_RAM_CHECK_ERROR*<br>*COMM_RAM_CHECK_ERROR*<br>*FSP_RAM_CHECK_ERROR*<br>*CTRL_RAM_COMPLEMENT_ERROR*<br>*COMM_RAM_COMPLEMENT_ERROR*<br>*xxx_RAM_COMPLEMENT_ERROR* | **End user:**<br>Restart the inverter by disconnecting AC and DC, using the switches. If the event persists, call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange board or inverter. |

| Event ID 241 | Display Text | Action |
|---|---|---|
| **Description:**<br>No contact to sensor | *I2C_FAULT* | **End user:**<br>Restart the inverter by disconnecting AC and DC, using the switches. If the event persists, call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange board or inverter. |

| Event ID 242 | Display Text | Action |
|---|---|---|
| **Description:**<br>Communication between inverter and control board failed for more than 10 seconds | *SPI_FAULT* | **End user:**<br>Restart the inverter by disconnecting AC and DC, using the switches. If the event persists, call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange board or inverter. |

| Event ID<br>243-244, 249 | Display Text | Action |
|---|---|---|
| **Description:**<br>Internal communi-cation error | *FPGA_WATCHDOG_TIMEOUT*<br>*FSP_WATCHDOG_TIMEOUT*<br>*FSP_COMM_FAULT* | **End user:**<br>Restart the inverter by disconnecting AC and DC, using the switches. If the event persists, call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange board or inverter. |

| Event ID 245 | Display Text | Action |
|---|---|---|
| **Description:**<br>Cannot be displayed after software version 2.01 (new communication boards introduced week 37, 2010) | *EVT_COVER_OPEN* | **End user:**<br>**Installer:**<br>**Service:** |

| Event ID 246 | Display Text | Action |
|---|---|---|
| **Description:**<br>Functional safety processor detected grid event | *FSP_GRID_EVENT* | **End user:**<br>Check event log for other grid events (1-55) and follow the instructions for these events.<br>If the event persists, call the installer.<br>**Installer:**<br>If the event persists after 24 hours, call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 247 | Display Text | Action |
|---|---|---|
| **Description:**<br>A plausibility fault has occurred in the functional safety processor | *FSP_PLAUSIBILITY_FAULT* | **End user:**<br>Check event log for other grid events (1-55) and follow the instructions for these events.<br>If the event persists, call the installer.<br>**Installer:**<br>If the event persists after 24 hours, call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 248, 251 | Display Text | Action |
|---|---|---|
| **Description:**<br>The self-test has failed | *SELF_TEST_FAILED FSP_FAIL_SAFE* | **End user:**<br>Check event log for other grid events (1-55) and follow the instructions for these events. If the event persists, call the installer.<br>**Installer:**<br>If the event persists after 24 hours, call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 255-257 | Display Text | Action |
|---|---|---|
| **Description:**<br>Islanding event logged | *UGRID_ABS_MEAN_HIGH_L1*<br>*UGRID_ABS_MEAN_HIGH_L2*<br>*UGRID_ABS_MEAN_HIGH_L3* | **End user:**<br>Check event log for other grid events (1-55) and follow the instructions for these events. If the event persists, call the installer.<br>**Installer:**<br>If the event persists after 24 hours, call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 255-257 | Display Text | Action |
|---|---|---|
| **Description:**<br>DC bus overvoltage | *UDCPROTECT_OVERVOLTAGE* | **End user:**<br>If the event persists for 2-3 days, call the installer.<br>**Installer:**<br>Check PV installation/layout. If OK, and if event reoccurs after 24 hours, call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 259 | Display Text | Action |
|---|---|---|
| **Description:**<br>Internal parameter is too low | *SELF_TEST_4_4_INTERNAL_PARAMETER_TOO_LOW* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 260 | Display Text | Action |
|---|---|---|
| **Description:**<br>Unable to change the voltage between ground and neutral during isolation test (by less than 10 V) | *SELF_TEST_4_4_VEN_TOO_LOW* | **End user:**<br>Call the installer.<br>**Installer:**<br>Check the PV installation for isolation error. If OK, call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 261 | Display Text | Action |
|---|---|---|
| **Description:**<br>Short-circuited booster transistor or wrong PV polarity | *SELF_TEST_4_6_SHORT_CIRCUIT* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter |

| Event ID 262 | Display Text | Action |
|---|---|---|
| **Description:**<br>Short-circuited booster transistor or wrong PV polarity | *SELF_TEST_4_6_SHORT_CIRCUIT_WRONG_POLARITY* | **End user:**<br>Call the installer.<br>**Installer:**<br>Check the PV installation for polarity errors. If OK, exchange the inverter.<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 263 | Display Text | Action |
|---|---|---|
| **Description:**<br>Internal software error | *INTERNAL_ERROR* | **End user:**<br>Check event log to see if this is logged more than once per day:<br>• If no: no action required<br>• If yes: call the installer<br>**Installer:**<br>Update software to latest version.<br>**Service:**<br>Exchange the inverter. |

| Event ID 350 | Display Text | Action |
|---|---|---|
| **Description:**<br>DC bias in RCMU is too high during self-test | *SELF_TEST_4_5_DC_BIAS_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 351 | Display Text | Action |
|---|---|---|
| **Description:**<br>DC bias in RCMU is too high during self-test | *SELF_TEST_4_5_RMS_BIAS_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 352 | Display Text | Action |
|---|---|---|
| **Description:**<br>RCMU cannot detect step (of 25 mA) in residual current | *SELF_TEST_4_5_STEP_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 353 | Display Text | Action |
|---|---|---|
| **Description:**<br>Short-circuited inverter transistor (AC) | *SELF_TEST_4_6_CURRENT_AT_OPEN_I GRID_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 354 | Display Text | Action |
|---|---|---|
| **Description:**<br>Short-circuited inverter transistor (AC) (average) | *SELF_TEST_4_6_CURRENT_AT_OPEN_I GRID_AVG_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 356 | Display Text | Action |
|---|---|---|
| **Description:**<br>Test of inverter relay and voltage measurements cannot be performed | *SELF_TEST_4_7_INVERTER_BIAS_FAILE D* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 357 | Display Text | Action |
|---|---|---|
| **Description:**<br>Inverter relay has failed (contact assumed welded) | *SELF_TEST_4_7_INVERTER_RELAY_FAIL ED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 358 | Display Text | Action |
|---|---|---|
| **Description:**<br>Inverter relay has failed (contact assumed welded) | *SELF_TEST_4_7_INVERTER_INV_VOLTA GE_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 359 | Display Text | Action |
|---|---|---|
| **Description:**<br>Inverter relay or transistor has failed (assumed open circuit) | *SELF_TEST_4_7_INVERTER_RELAY_INV_UPPER_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 360 | Display Text | Action |
|---|---|---|
| **Description:**<br>Inverter relay or transistor has failed (assumed open circuit) | *SELF_TEST_4_7_INVERTER_RELAY_INV_LOWER_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 361 | Display Text | Action |
|---|---|---|
| **Description:**<br>Grid relay has failed (assumed open circuit) | *SELF_TEST_4_8_GRID_DIF_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Check and/or fix the neutral wire.<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 362 | Display Text | Action |
|---|---|---|
| **Description:**<br>Neutral relay has failed (inverter relay assumed welded) | *SELF_TEST_4_9_NEUTRAL_INV_RELAY_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Check and/or fix the neutral wire.<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 363 | Display Text | Action |
|---|---|---|
| **Description:**<br>Neutral relay has failed (grid relay assumed welded) | *SELF_TEST_4_9_NEUTRAL_GRID_RELAY_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Check and/or fix the neutral wire.<br>Call service.<br>**Service:**<br>Exchange the inverter. |

| Event ID 364 | Display Text | Action |
|---|---|---|
| **Description:**<br>Neutral connection is damaged or missing | *SELF_TEST_4_9_NEUTRAL_RELAYS_FAILED* | **End user:**<br>Call the installer.<br>**Installer:**<br>Check AC installation for failures on neutral connection. Call service.<br>**Service:** Verify that the AC installation is correct according to the installation manual. Verify that the neutral wire is correctly connected. The failure is most likely in the installation. |

## 12.1.5 Communication Events

| Event ID 1 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Dynamic memory allocation failed | eNoMemory | ✓ | | **End user:**<br>Reset the inverter by disconnection. If the event persists, call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Report the error. |

| Event ID 3 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Incoming data buffer overflowed (modem response too long) | eModemBufferInO-verflow | ✓ | | **End user:**<br>Reset the inverter by disconnection. If the event persists, call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Report the error. |

| Event ID 4 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Current modem command received "ERROR" response | eModemCmdReplyError | ✓ | | **End user:**<br>Reset the inverter by disconnection. If the event persists, call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Report the error. |

| Event ID 5 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Current modem command timed out. GSM is not connected or it has a serious problem because it did not respond to last AT command. | eModemCmdTimeout | ✓ | | **End user:**<br>Call the installer.<br>**Installer:**<br>**End user:**<br>Open the cover and check if the modem is installed. Verify that the SIM card is installed and working. This is done by moving the SIM card to a phone. If problem persists, call service.<br>**Service:**<br>Exchange the GSM module. |

| Event ID 7 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Modem's low-level initialisation failed. The GSM module has a serious problem. | eModemInitFail | ✓ | | **End user:**<br>Call the installer.<br>**Installer:**<br>**End user:**<br>Open the cover and check if the modem is installed. Verify that the SIM card is installed and working. This is done by moving the SIM card to a phone. If problem persists, call service.<br>**Service:**<br>Exchange the GSM module. |

| Event ID 9 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Internal fault, unexpected state. | eUnexpectedState | ✓ | | **End user:**<br>Reset the inverter by disconnection. If the event persists, call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Report the error. |

| Event ID 10 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Modem response not recognised | eModemReplyParse-Failed | ✓ | | **End user:**<br>Reset the inverter by disconnection. If the event persists, call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Report the error. |

| Event ID 11 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Upload failed, not logged into home nor roaming (if allowed) GSM network.<br>GM logs on and off GSM network. Indicates poor signal reception. | eConnectionUna-vailable | ✓ | | **End user:**<br>Only take action if the event reoccurs.<br>• Check GSM signal strength<br>- If not OK, try a different provider<br>• Check if the SIM cards work (in a mobile phone).<br>- Call the installer<br>**Installer:**<br>Install router with built-in GSM modem and place it for better reception.<br>**Service:**<br>None. |

| Event ID 12 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to open upload connection (generic). Something other than GPRS or FTP failed. | eModemLinkOpenFail | ✓ | | **End user:**<br>Only take action if the event reoccurs.<br>• Check GSM signal strength<br>- If not OK, try a different provider<br>• Check if the SIM cards work (in a mobile phone)<br>• Other FTP server: Try to configure another/different FTP server<br>If event persists, call the installer.<br>**Installer:**<br>Call service.<br>**Service:** Report the error. |

| Event ID 13 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to close connection (FTP or GPRS) after upload. Not critical, data was sent OK. | eModemLinkCloseFail | ✓ | | **End user:**<br>Not a serious event. If the event reoccurs, inform the installer.<br>**Installer:**<br>Call service.<br>**Service provider:** Report the error. |

| Event ID 17 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Uploaded file size check did not match. Part of the file was probably lost.<br>The upload file was corrupted during upload. | eUploadFileSize | ✓ | ✓ | **End user:**<br>Call the installer.<br>**Installer:**<br>Change FTP server configuration (spec. defining supported FTP configuration needed).<br>**Service:**<br>None. |

| Event ID 18 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Modem did not connect to any GSM network.<br>Either GSM coverage is missing or SIM card is not activated. | eModemNoNetwork | ✓ | | **End user:**<br>• Check GSM signal strength<br>- If not OK, try a different provider<br>• Check if the SIM cards work (in a mobile phone)<br>**Installer:**<br>Install router with built-in GSM modem and replace for better reception.<br>**Service:**<br>None. |

| Event ID 19 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>SIM card did not respond to PIN query. SIM card is missing or has failed. | eModemSIMResponse | ✓ | | **End user:**<br>Check if the SIM card works (in a mobile phone) .<br>**Installer:**<br>Replace modem.<br>**Service:**<br>None. |

| Event ID 20 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Upload file exists on server (with exactly the same serial and time stamp in name). DWH refuses to overwrite existing log files on server. | eUploadFileExists | ✓ | | **End user:**<br>Avoid uploading to the same FTP server from different sites.<br>**Installer:**<br>Change FTP server configuration (spec. defining supported FTP configuration needed). If the problem persists, call service.<br>**Service:** Report the error. |

| Event ID 21 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to parse modem manufacturer. | eModemParseMfgr | ✓ | | **End user:**<br>Call the installer.<br>**Installer:**<br>Replace modem.<br>**Service:**<br>None. |

| Event ID 22 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to parse modem model. | eModemParseModel | ✓ | | **End user:**<br>Call the installer.<br>**Installer:**<br>Replace modem.<br>**Service:**<br>None. |

| Event ID 23 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to parse modem revision. | eModemParseRvsn | ✓ | | **End user:**<br>Call the installer.<br>**Installer:**<br>Replace modem.<br>**Service:**<br>None. |

| Event ID 24 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to parse modem RSSI. | eModemParseRSSI | ✓ | | **End user:**<br>Call the installer.<br>**Installer:**<br>Replace modem.<br>**Service:**<br>None. |

| Event ID 26 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>SIM card requests a code, but it is not PIN (commonly PUK, because SIM is locked). | eModemSecurityNotPIN | ✓ | | **End user:**<br>This SIM card is blocked. Find the PUK code, insert the SIM into a mobile phone and unblock it. Try a different provider.<br>**Installer:**<br>None.<br>**Service:**<br>None. |

| Event ID 27 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to parse response to pin status query. | eModemParsePINStatus | ✓ | | **End user:**<br>Reset the inverter by disconnection. If the event persists, call the installer.<br>**Installer:**<br>Call service.<br>**Service:**<br>Report the error. |

| Event ID 28 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to parse response to network registration status query. | eModemParseNe-tRegStat | ✓ | | **End user:**<br>Power-cycle the inverter.<br>**Installer:**<br>Replace modem. If that does not help, call service.<br>**Service provider:**<br>Report the error. |

| Event ID 29 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Internal fault, unexpected MCH initialisation state. | eUnexpectedInitState | ✓ | | **End user:**<br>**Installer:**<br>**Service:**<br>Report the error. |

| Event ID 30 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to set PIN code. The PIN code is wrong. Be careful – if the inverter is reset, it will set the same PIN code again. After two resets, the SIM will block because it received 3 attempts to set wrong PIN. | eModemSetPIN | ✓ | | **End user:**<br>See description.<br>If the card is blocked, put it in a mobile phone and use the PUK code to unlock.<br>**Installer:**<br>None.<br>**Service provider:**<br>None. |

| Event ID 31 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to set GPRS access point name (APN).<br>APN is invalid. Use only alpha-numeric (a-z, A-Z, 0-9) and dot (.) characters. | eGPRSParams | ✓ | | **End user:**<br>APN is invalid. Use only alpha-numeric (a-z, A-Z, 0-9) and dot (.) characters.<br>**Installer:**<br>None.<br>**Service:**<br>None. |

| Event ID 33 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to set GPRS username.<br>User name is invalid. Avoid white space. | eGPRSAuthPasswd | ✓ | | **End user:**<br>User name is invalid. Avoid white space.<br>**Installer:**<br>None.<br>**Service:**<br>None. |

| Event ID 34 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to set GPRS password.<br>Password is invalid. Avoid white space. | eGPRSAuthPasswd | ✓ | | **End user:**<br>User name is invalid. Avoid white space.<br>**Installer:**<br>None.<br>**Service:**<br>None. |

| Event ID 35 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to open GPRS connection. | eGPRSOpe | ✓ | | **End user:**<br>Many things can cause the GPRS connection to fail. The APN, username or password might be wrong. Ask GSM provider for GPRS configuration. Maybe GPRS is not enabled for the SIM in question?<br>**Installer:**<br>None.<br>**Service:**<br>None. |

| Event ID 36 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to open FTP connection. | eFTPOpen | ✓ | ✓ | **End user:**<br>• Possible causes:<br>- No internet connection<br>- Wrong FTP server address<br>- Wrong username or password<br>• Try to connect to the FTP server from the PC.<br>- Verify that the inverter has access to the internet<br>**Installer:**<br>None.<br>**Service:**<br>None. |

| Event ID 37 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to set FTP mode. The server refused to accept binary mode transfer. This should not happen in production release when uploading to current Meteocontrol FTP server. | eFTPTransferType | ✓ | | **End user:**<br>Call the installer.<br>**Installer:**<br>Change the FTP server configuration (spec. defining supported FTP configuration. needed). Call service.<br>**Service:**<br>Report the error. |

| Event ID 38 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to change FTP directory (only if FTP directory has been specified). | eFTPChdir | ✓ | | **End user:**<br>Call the installer.<br>**Installer:**<br>Change the FTP server configuration (spec. defining supported FTP configuration needed). Call service.<br>**Service:**<br>Report the error. |

| Event ID 39 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to start file upload.<br>Uploading the file fails when the server refuses it or when there is a problem with the internet connection. Maybe the firewall blocks active mode FTP? | eFTPPut | ✓ | ✓ | **End user:**<br>Uploading the file fails when the server refuses it or when there is a problem with the internet connection. Maybe the firewall blocks active mode FTP?<br>**Installer:**<br>None.<br>**Service:**<br>None. |

| Event ID 40 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to read uploaded file back to verify.<br>Getting the file listing from FTP server failed.<br>This indicates that there is a problem with the server or internet connection. | eUploadFileRead | ✓ | | **End user:**<br>Call the installer.<br>**Installer:**<br>Change the FTP server configuration (spec. defining supported FTP configuration needed).<br>**Service:**<br>Report the error. |

| Event ID 41 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>There is no data log to upload. All unsent log has been sent and inverter has not yet generated any new log.<br>This is not an error. It just indicates that all logged data that need uploading have already been uploaded. | eNoData | ✓ | | **End user:**<br>**Installer:**<br>**Service:** |

| Event ID 42 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>The master inverter's RTC is not set. Inverter time and date must be set for uploads to occur. | eTimeNotSet | ✓ | ✓ | **End user:**<br>Call the installer.<br>**Installer:**<br>Set time and date.<br>**Service:**<br>None. |

| Event ID 43 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>The master inverter's serial number is invalid. | eInvalidSerial | ✓ | | **End user:**<br>Call the installer.<br>**Installer:**<br>Call the service provider.<br>**Service provider:** Fix serial number. |

| Event ID 44 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>The SIM PIN code is not valid.<br>A PIN code must be 4-8 characters long and consist only of digits.<br>No other characters are permitted. | eInvalidPIN | ✓ | | **End user:**<br>A PIN code must be 4-8 characters long and consist only of digits.<br>No other characters are permitted.<br>**Installer:**<br>None.<br>**Service:**<br>None. |

| Event ID 45 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to open FTP file for uploading. | eModemFileOpenFail | ✓ | | **End user:**<br>Call the installer.<br>**Installer:**<br>Change the FTP server configuration (spec. defining supported FTP configuration. needed). Call service.<br>**Service:**<br>Report the error. |

| Event ID 46 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to send an SMS. This error does not occur when uploading to data warehouse. | eModemSendSMSFail | | | **End user:**<br>Move SIM to a phone and try to send SMS. Possible cause: lack of credit Try different SIM cards.<br>**Installer:**<br>Call service.<br>**Service:**<br>Report the error. |

| Event ID 47 | Label | GSM | LAN | Action |
|---|---|---|---|---|
| **Description:**<br>Failed to send an email via GSM.<br>This error does not occur when uploading to data warehouse. | eModemSendEmailFail | | | **End user:**<br>Move SIM to a phone and try to send email. Possible cause: lack of credit.<br>Try different SIM cards.<br>**Installer:**<br>Call service.<br>**Service:**<br>Report the error. |

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